VOL. XXXIII. — No. 7. JULY 1956.

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Monthly Bulletin of the International Railway Congress Association

(English Edition)

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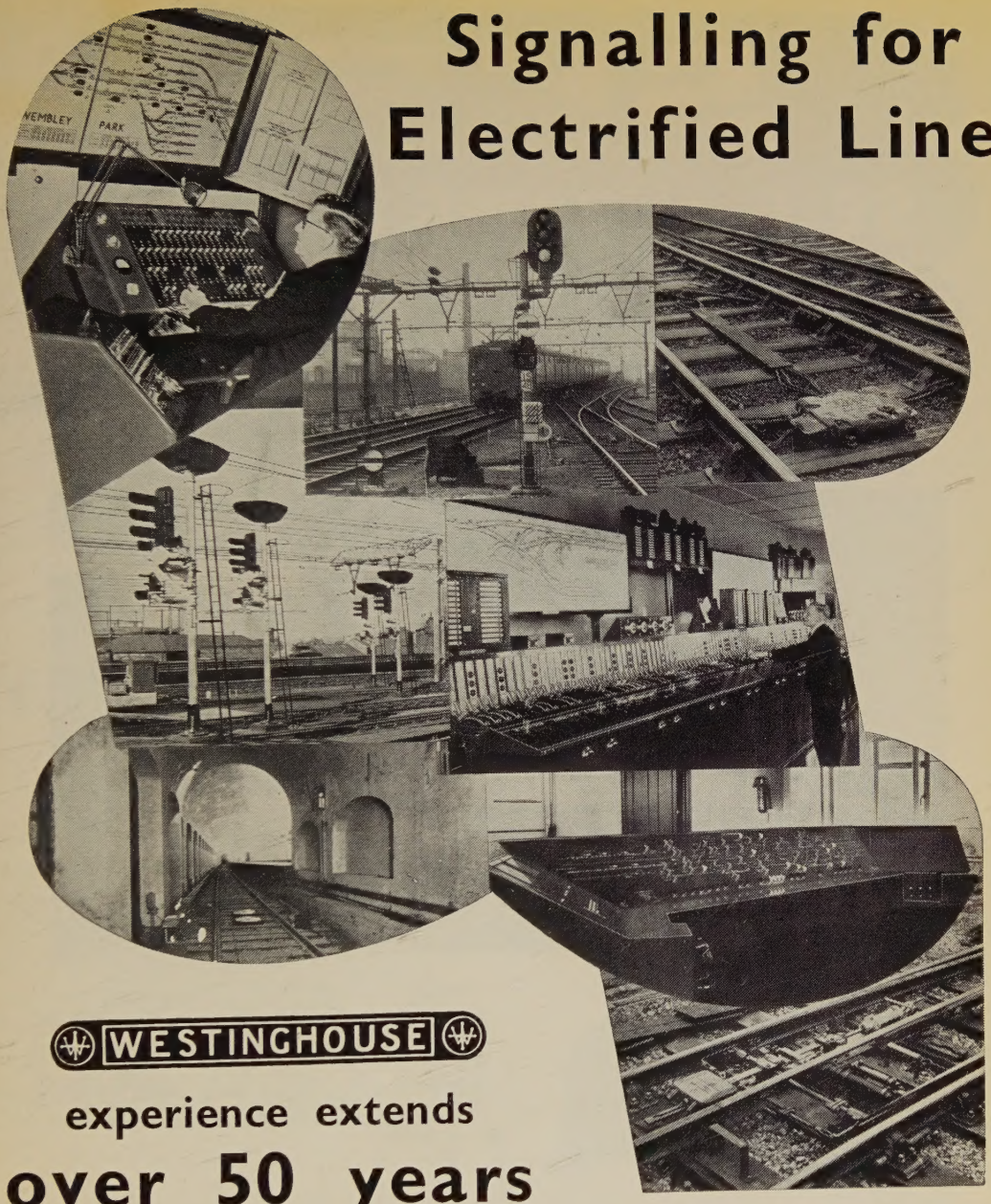

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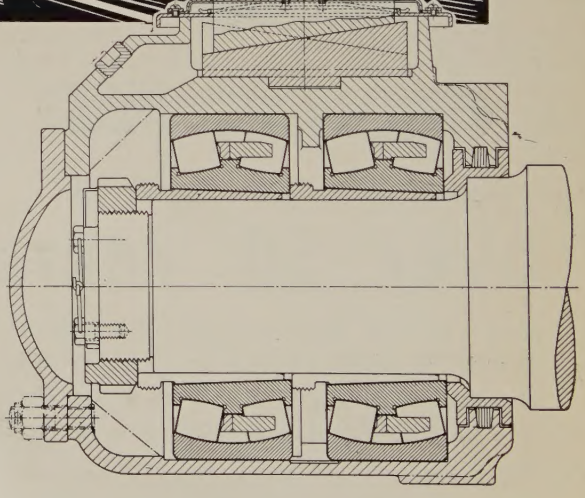

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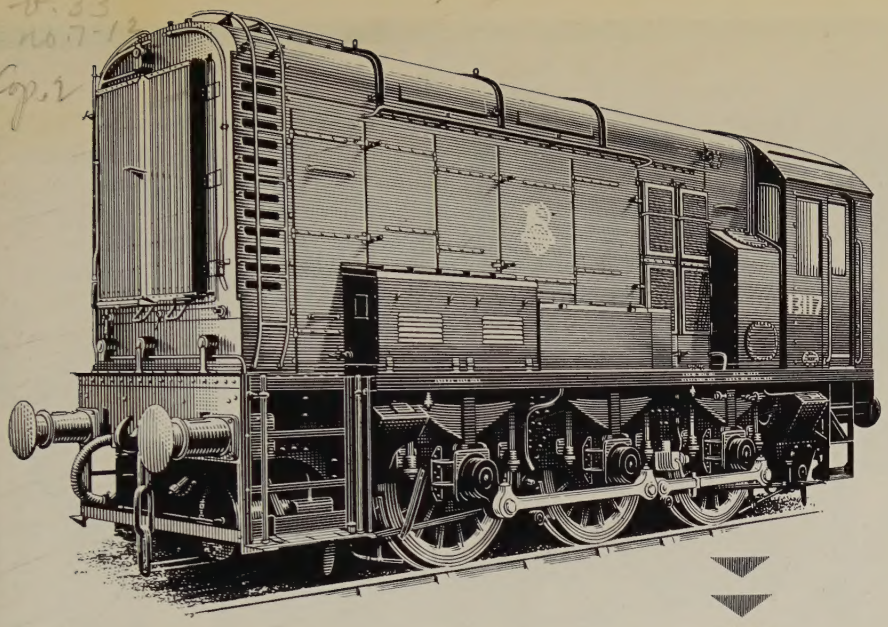

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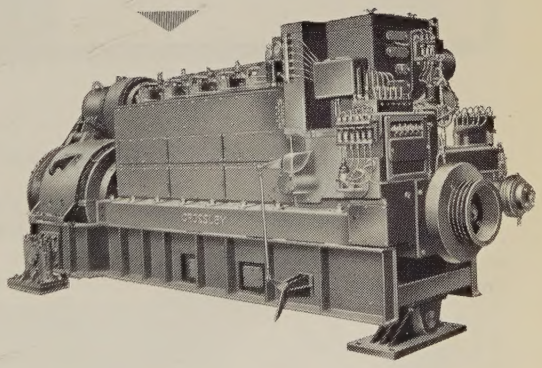

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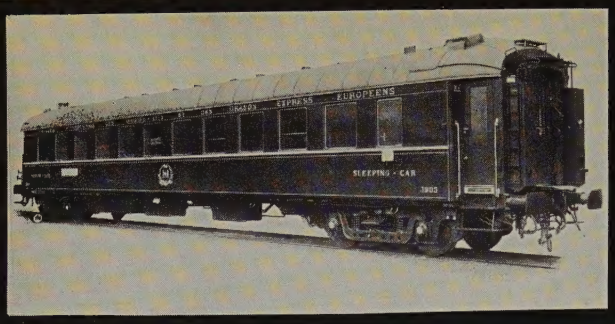

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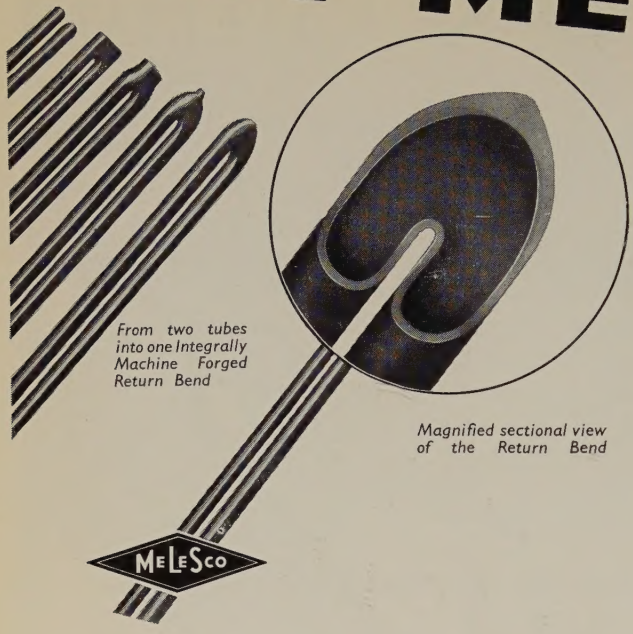

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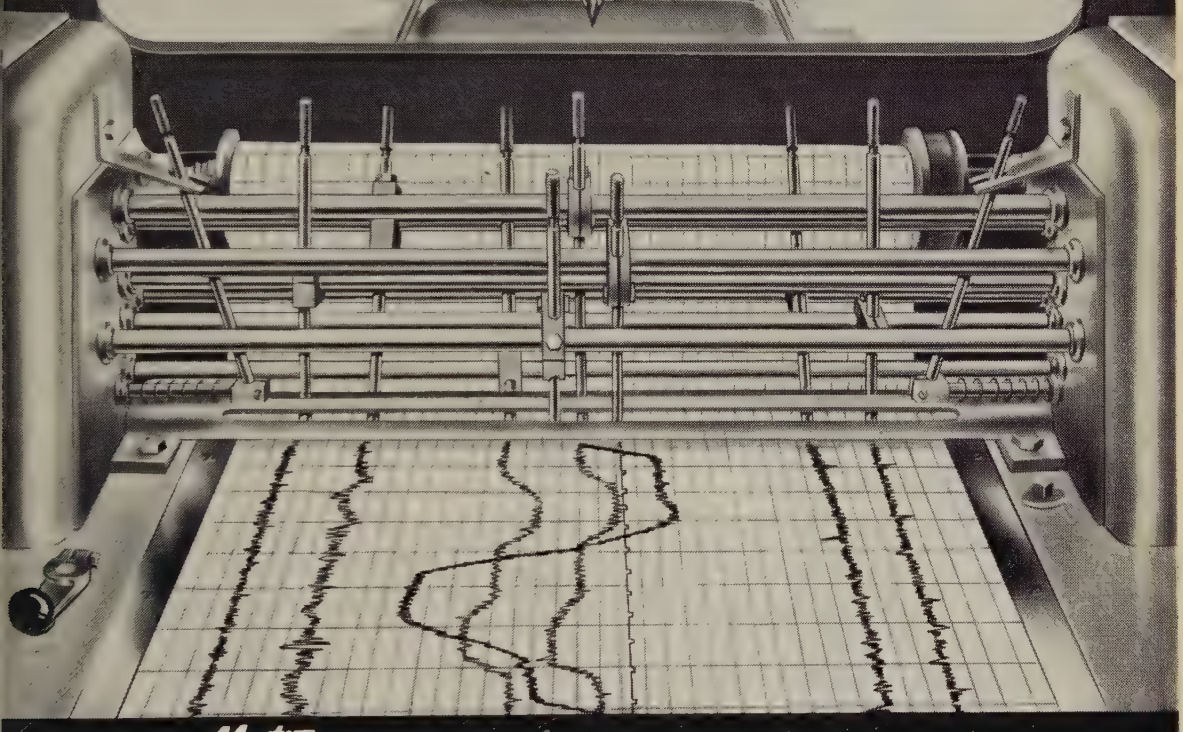

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MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(ENGLISH EDITION)

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An edition in French is also published.

Vol. XXXIII. — No. 7. July 1956.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

Enlarged Meeting of the Permanent Commission at The Hague-Scheveningen

(4th to 6th June, 1956.)

The Permanent Commission held at The Hague-Scheveningen, from the 4th to 6th June, 1956, several technical sessions, which were attended by most of its members and at the same time by a number of their assistants, i.e. Engineers and High Officials belonging to the large Railway Systems.

The programme of the technical sessions included the examination of the three following questions :

I. « Research on the economic usefulness and the technical opportunity to install a third track, serving for common use (banalisation), in addition to sections of double track lines with heavy traffic, instead of installing two double track lines on such sections.

« Consequences of the installation of a third track for use in either direction on the conditions necessary to insure the safety of train movements. »

II. « In a system of standard, narrow or broad gauge lines which has Diesel traction for shunting and for main line working, what are the conditions governing :

« 1° the choice of the characteristics and kind of transmission;

« 2° the most economical organisation, maintenance and operation.

« Research into savings that might be possible in comparison with steam traction. »

III. « Development of railway tariffs.

« Economic justification of these tariffs.

« Adjustment of tariffs to the new conditions of the general economic system and to the other forms of transport.

« Function of tariffs in coordination of inland transport. »

The study of these three questions was decided at the Meeting of the Permanent Commission of the 13th November 1954.

* * *

We will publish in one of our next Bulletins the summary of the proceedings in the Sections and Plenary Meeting, as well as the names of the members of the Permanent Commission and their assistants, who attended the technical meetings. However, we give hereafter the complete text of the Summaries adopted during the Enlarged Meeting at The Hague.

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OFFICIAL INFORMATION

ISSUED BY THE

PERMANENT COMMISSION

OF THE

International Railway Congress Association.

Meetings held by the Permanent Commission at The Hague-Scheveningen (4th to 6th June 1956).

Meeting of the Permanent Commission held on June 4, 1956.

A first meeting of the Permanent Commission was held on the 4th of June last at the *Palace Hotel*, at Scheveningen.

The session, which opened at 9.30 a.m., was presided by Mr. M. De Vos, *General Manager of the Belgian National Railways and President of the Association.*

After having extended a welcome to the numerous personalities present, the President expressed on behalf of the Assembly, his most sincere thanks to Mr. F.Q. den Hollander, *President of the Netherlands Railways*, for the hearty welcome reserved to the delegates on their arrival in the Netherlands. The President then opened the discussion of the Agenda.

He submitted to the approval of the Meeting the Minutes of the Session of the 22nd October 1955, which were confirmed.

* * *

Mr. Ghilain, *General Secretary*, submitted to the Assembly the following proposals for the nomination of members of the Permanent Commission :

Mr. Gamal Salem, Minister of Communications, Egypt, to replace Mr. Fathy Radwan, his predecessor, nominated Minister of National Orientation;

Mr. S. Isozaki, Director of the Foreign Affairs Department of the Japanese National Railways, to replace his predecessor, Mr. Manabu Kanematsu, promoted to other functions;

Mr. R.F. Marriott, Advisory Engineer, representing the New Zealand Government Railways in London, to succeed Mr. R.J. Harvey, Consulting Engineer, now nominated Member of Honour;

Mr. L. Gehorsam, Director of the Testing and Research Railway Institute of Poland, to replace Mr. Wagner, First Adviser of the International Relations Department of the Ministry of Railways, Poland, who has resigned.

— *These proposals were adopted by the Meeting.*

— *The Appendix hereafter gives the present list of members of the Permanent Commission.*

The Assembly then formed the Bureau of each of the Sections for the technical Sessions to be held on June 4, 5 and 6, as follows :

SECTION I

Way and Works — Working :

President :

Mr. David BLEE, Traffic Adviser, British Transport Commission, member of the Permanent Commission of the Association, replacing Mr. C.K. BIRD, General Manager, Eastern Region, British Railways, unable to attend for health reasons.

Vice-Presidents :

Mr. J. DE AGUINAGA, Director General de Ferrocarriles, Tramvias y Transportes por Carretera (Spain), member of the Permanent Commission of the Association, and

Mr. M. SCHANTL, General Manager of the Austrian Federal Railways, member of the Permanent Commission of the Association.

Principal Secretary :

Mr. MARCHAL, First Engineer, Belgian National Railways.

Secretaries :

Mr. G. PINSON, Inspecteur à la Division des Etudes d'Exploitation de la Région Ouest de la Société Nationale des Chemins de fer Français, and

Mr. E.G. BRENTNALL, Assistant Signal Engineering Officer, British Railways.

SECTION II

Locomotives and Rolling Stock :

President :

Mr. A. PORCHEZ, Directeur Général Adjoint de la Société Nationale des Chemins de fer Français, member of the Permanent Commission of the Association.

Vice-Presidents :

Dr. F. SCHELP, Präsident der Deutschen Bundesbahn, member of the Permanent Commission of the Association, and

Dr. Ing. A. CUTTICA, Vice-Directeur Général des Chemins de fer de l'Etat Italien, member of the Permanent Commission of the Association.

Principal Secretary :

Mr. R. SQUILBIN, First Engineer, Belgian National Railways, Technical Secretary of the Association.

Secretaries :

Mr. G. OBERREINER, Inspecteur, Service M T, Région Sud-Est, Société Nationale des Chemins de fer Français, and

Mr. A.E. BERESFORD, Engineer, British Railways.

SECTION IV

General :

President :

Mr. F.Q. DEN HOLLANDER, President, Netherlands Railways, member of the Permanent Commission of the Association.

Vice-Presidents :

Dr. H. GSCHWIND, Président de la Direction Générale des Chemins de fer Fédéraux Suisses, member of the Permanent Commission of the Association, and

Mr. M. DIAS-TRIGO, Directeur des Services d'Exploitation et du Matériel de la Direction des Transports terrestres au Ministère des Travaux Publics et des Communications du Portugal, member of the Permanent Commission of the Association.

Principal Secretary :

Mr. COLLE, Engineer, Belgian National Railways.

Secretaries :

Mr. G.M. BUREAU, Inspecteur, Société Nationale des Chemins de fer Français, and

Mr. R.H. KITCHING, Assistant to Chief Officer (Marine & Administration) British Transport Commission.

* * *

Mr. J.L. HARRINGTON, Chief Officer (Marine & Administration), British Transport Commission, was appointed English Assistant General Secretary.

* * *

Mr. GHILAIN then informed the Meeting of a request for membership received by the Association from the Union of Soviet Socialist Republics (U.S.S.R.).

According to Art. 4 of the Rules and Regulations, it has been proceeded to a written ballot amongst the Members of the Permanent Commission concerning the addition of this country to the List of countries belonging to the Association.

The majority of three quarters of the total votes being obtained, it is proposed to include the U.S.S.R. in the list of countries, appendix to the Rules and Regulations, and to agree to this request for membership to our Association.

Moreover, following the admission of the U.S.S.R. within the Association, it is proposed to grant to that country a seat on the Permanent Commission. *(Approved).*

Mr. GHILAIN stated to the Assembly that a representative of the U.S.S.R.'s Embassy in The Hague, will attend as observer our meetings at Scheveningen.

* * *

The *General Secretary* recalled that during the Meeting of the 22nd October 1955, it was decided to examine and definitively agree upon the agenda of the *Madrid Congress* to be held in 1958. The proposals received from the Member Administrations and the members of the Permanent Commission have been included in a choice of questions drafted in a manner to embody the most interesting suggestions which have been formulated.

It is proposed to take as a basis a figure of ten questions, i.e. two questions for each section.

After examination and discussion of the proposed subjects, the Meeting drew up the List of questions to be discussed at the Madrid Session.

— Certain proposed questions, however, having been altered, the text needs to be checked, and we will publish in one of our next Bulletins the final List of Questions chosen.

Mr. GHILAIN submitted to the Assembly a draft for the designation per country of the various reporters called to study the different questions on the agenda.

With regard to the functions of President of Section, it was decided to allocate them as follows :

1st Section — Way and Works : Spain.

2nd Section — Locomotives and rolling stock : Great Britain.

3rd Section — Working : France.

4th Section — General : Switzerland.

5th Section — Light Railways and Colonial Railways : Italy.

The Vice-Presidencies will be allotted to the other countries.

* * *

Mr. GHILAIN mentioned afterwards, that no new affiliation or resignation occurred since the meeting of the 22nd October last.

He gave particulars on the financial position of the Association before the closing of the meeting.

MEETING OF THE PERMANENT COMMISSION OF THE 6TH JUNE, 1956

— The meeting which took place in the *Kurhaus Hotel*, opened at 10 a.m., and Mr. DE VOS, *President of the Association*, was in the chair.

The PRESIDENT stated that the only item of the agenda was the ratification of the Summaries adopted in the three Sections during the technical meetings.

— The text of the Summaries submitted was adopted without modification.

The General Secretary, (s) P. GHILAIN. *The President,* (s) M. DE VOS,

* * *

The technical meetings were held in the premises of the *Palace Hotel* at Scheveningen.

The opening session took place in the Hall of Knights (Ridderzaal) in The Hague, historic building in Gothic style, where every year *H. M. the Queen* presides the great ceremony of the opening of Parliament. This meeting was enhanced by the presence of H. Exc. the Minister of Transport and Waterstaat, Mr. ALGERA.

Mr. DE VOS, *President of the Association*, opened the Meeting and called upon Mr. SCHOKKING, Mayor of The Hague.

Mr. SCHOKKING, in a speech full of humour and sympathy, recalled the role of his town as the centre of numerous International Congresses, as well as the interest he has always devoted to railway matters. He mentioned in particular the importance of the problem relating to the stations, which in the case of The Hague, has been the subject of profitable deals with the Management of the Netherlands Railways. He wishes every success for the works of the Meeting and ended by a warm welcome to the participants on behalf of the City of The Hague.

Mr. DE VOS, expressed his gratitude for the honour rendered to the Enlarged Permanent Commission by the Netherlands, by greeting its members in the historical « Ridderzaal », which played a so important part in the history of the country. He recalled in particular that still nowadays, it is in this venerable hall that the gracious Sovereign of the Netherlands presided every year the opening ceremony of Parliament.

He suggested to address a telegram to H. M. the Queen and read out the wording.

Then, he expressed his thanks to H. Exc. the Minister of Transport and Waterstaat, whose presence gave evidence of his interest in the progress of the railways and in the works of the Association. He also paid a tribute to the Mayor of The Hague for the hearty welcome given to the Delegates as well as to Mr. DEN HOLLANDER, President of the Netherlands Railways, his colleagues and all his collaborators for their work in the organisation of the session, which gave promise of a successful Meeting. Speaking next of the technical programm of the session, he pointed out the importance of the problems on the agenda and paid a special tribute to the works of the Reporters. With regard to the Question relative to railway tariffs, he spoke about the difficulties being met at the present time by the various Railway Systems and of the usefulness of recommending a sound competition between the different methods of transport. Finally, he expressed his hope for the success of the Meeting.

Mr. ALGERA, *Minister of Transport and Waterstaat*, then delivered the following speech :

« Mr. President,

« Ladies and Gentlemen,

« The Netherlands Government, in whose name I have the honour to address you in a few words at the opening of your meeting desires me to wish you a most cordial welcome.

« This is the first time that this « Enlarged Meeting of the Permanent Commission » has taken place in our country. We are congratulating ourselves thereon. We consider the fact that your organisation has selected Holland for its meeting place this year is a privilege, but I am also very happy to be able to bear witness to the important work being done by meetings such as this one within the framework of the International Railway Congress Association.

« Its history proves that the existence of such an Association is well justified. It was in 1886, in fact, that the International Railway Commission was created by the members of the Organising Committee of the Railway Congress and its officials, at the Congress which was held in 1885 at Brussels. In 1887, at the Milan Congress, which was organised by the aforementioned International Commission, the International Railway Congress Association first saw the light of day. It is therefore seventy years since the International Commission was set up. I consider that this Commission can be considered as the precursor of the Permanent Commission. Even though, on account of the interruptions which your work has suffered owing to the two world wars, it is not possible to speak of a continuous work of 70 years, the vitality which your organisation shows 70 years

after its first foundation, commands our admiration and proves that it does indeed fill a gap.

« You have come from the most diverse parts of the world to meet here and deal with railway problems. This time you are not doing this in the guise of a spectacular Congress but in the form of an Enlarged Meeting of the Permanent Commission, and this is the fifth time that you have met in this way. The subjects you are going to discuss are of the greatest importance. They illuminate the fact that the Railway still occupies an important place in our economic and social life, in spite of all the changes that have taken place during these last seventy years. These changes are in fact innumerable. If we limit ourselves to transport only, we see that in this field the motor car and the aeroplane have made a place for themselves besides the train and the ship. The proportions in which the aeroplane, the motor, the train and the ship share in the transport of a country differ in each one of the countries from which you come, but there is one certain fact, and that is that in every country the railway is still indispensable.

« This does not mean however that the Railways no longer need to fight to maintain their position in the social life of the country. On the contrary. The development and progress made in the technical field are not the least of the reasons why the Railway still holds the place it now occupies.

« It is thanks to technical progress that the motor, the motorbus, the motor-lorry and the aeroplane have been able to play a competitive part in the field of transport, but it is also thanks to technical evolution that the Railway has been able to undergo a metamorphosis through which it has been able to accomplish its modernisation and rationalisation and thereby conserve and recover its vitality. I have only to pronounce the words « Electrification » and « Diesel Traction » and each one of you will understand how technique and economy together have strengthened the position of the Railway in the last dozen years or so, and this applies equally to passenger and freight transport. Here technique and economy go hand in hand. For this reason, it is not surprising that both of them belong to a field covered by the activities of your Association.

« At the beginning of your activities, you were dealing exclusively with technical matters. Economy then was added, as indeed it could not fail to be. The Agenda of your work which you are going to follow during the next few days is a faithful reflection of this point. I think it was a most happy idea that you included in your agenda besides such technical subjects as «The making of a third track » and «Diesel Traction », a subject connected with the economics of transport, such as « The evolution of the tariffs for railway transport ». The tariffs in fact constitute an important factor in the co-ordination of transport. May I be permitted, without wishing in any way to minimise the value of your technical subjects, to devote a few words to your third subject.

« As you appreciate, the creation of conditions which will allow of a healthy and economically justified co-ordination of the different branches of transport is indeed a vast problem. It is not the

moment to go into this question here, but perhaps I may be permitted to remind you that here in Holland we are in favour of the principle that the different branches of transport in our country must be considered as forming a single unit and that they must as far as possible enjoy the same rights and assume the same responsibilities, which means in fact that the same conditions of competition must exist for every branch of transport. Transport undertakings must be able to carry on in a way that is justifiable from the commercial point of view. In the case of the Railway, this means that they must « stand on their own feet ». The Railways are responsible for the transport of passengers and of freight. In my opinion, each of these two branches must be able to balance its own budget. For example, if the transport of freight can only pay its way thanks to the surplus receipts from the transport of passengers, then the transport of freight by rail is being carried out below its actual cost and the Railway is competing unfairly against other undertakings which carry freight by road or water. For this reason, it is of the utmost importance that the tariffs should be harmonised in an equitable manner and made to comply with the principles which I have just quoted. It was with the greatest interest that I noted your Commission had included the question of tariffs in its agenda.

« I am very glad that you are breaking off your work to take part in cultural meetings, festivities and excursions. In this way, you will be able to have a break from business and come into contact with the country in which your « meeting » is being held. This will also give this meeting a wider scope and in this way it will be able to contribute not only to improvements in railway affairs, but to an increase in our feelings of solidarity.

« With a sincere wish, Mr. PRESIDENT, that this «meeting » may prove in every way a successful session, I declare open the Fifth Enlarged Meeting of the Permanent Commission of the International Railway Congress Association. »

The PRESIDENT thanked the Minister of Transport for his so interesting speech and adjourned the session. A reception of the delegates in the « Rolzaal » closed the ceremony.

* * *

The technical meetings began on Monday 4th June at 3.15 p.m. The respective Sections went into the special reports drawn up on the three questions on the agenda and had interesting discussions in which the representatives of the chief railways took part.

These meetings were continued the next day, June 5, and the Summaries were discussed before being finally submitted for approval to the Plenary Meeting of the Permanent Commission on Wednesday, June 6.

This latter session took place at 10.00 a.m. and all the members of the Permanent Commission present in The Hague attended.

The Meeting, with Mr. DE VOS in the Chair, examined and discussed the proposals and summaries presented by the Bureau of each of the three Sections, and the final texts were unanimously approved (*).

(*) The final text of the Summaries adopted appears on pages 558 to 580 *of the present Bulletin.*

Mr. DE VOS, before closing the session, made a final speech in which he pointed out the great interest for the Railway Systems of the Summaries drawn up by the various Sections. He paid homage to the arduous work of the Reporters and Special Reporters, thanked the Presidents of Sections, Principal Secretaries and Secretaries for their competent collaboration during the works. He expressed also his special gratitude to Mr. DEN HOLLANDER, President of the Local Organizing Committee, as well as to Mr. AGHINA, Secretary, whose unceasing work had so much contributed to the success of the Meeting from both points of view : technique and pleasure.

Finally, he paid a tribute to the unwearing efforts of Mr. GHILAIN, General Secretary of the Association, and his English Assistant, Mr. HARRINGTON.

* * *

On the evening of the 4th June, there was the Banquet offered by the Permanent Commission to the Dutch Authorities and Members of the Commission, presided over by Mr. DE VOS. Toasts were given to H. M. the Queen and the Chiefs of States.

On Tuesday, June 5, a concert, sponsored by the Netherlands Railways was given in the Kurhaus by the Amsterdam Philharmonic Orchestra (Concertgebouworkest). It was followed by a fireworks display also sponsored by the Netherlands Railways.

On Wednesday, June 6, the Management of the Netherlands Railways invited all the delegates to attend a Banquet in the great Hall of the *Kurhaus Hotel.* This banquet was presided by Mr. DEN HOLLANDER, President of the Netherlands Railways.

After a toast in honour of Her Majesty the Queen of the Netherlands, and the Chiefs of the States represented in Scheveningen, a speech was made by Mr. DEN HOLLANDER. Mr. DE VOS replied on behalf of all the delegates and reiterated their warm feelings towards the Netherlands.

* * *

On Thursday, June 7, a party of delegates and their wives made an excursion to the centre of the oil industry of Pernis (Rotterdam) and visited the docks of Rotterdam. This excursion was sponsored by the Royal Dutch Petroleum Company.

The journey started by bus from the *Palace Hotel* in Scheveningen. After passing through Rotterdam, the delegates were welcomed under a tent installed near an experimental oil-well derrick, where engineers gave them a lecture on the history of the search for oil in the Netherlands. Afterwards, they were able to visit the drilling installation. Then, buses took the participants to an embarking place for the visit of the port of Rotterdam. Lunch was served on board the steamer. The delegates had the opportunity of admiring the spacious port installations in full activity.

During the journey, the boat with the delegates crossed the Royal Yacht with H. M. the Queen of Netherlands and H. G. the Grand Duchess of Luxemburg on board.

After the visit of the port installations, the party was received by the Management of the oil-refinery of the Royal-Dutch Petroleum Company at Pernis; tea was served, and afterwards they heard a

description of the plants. After this lecture, they had the pleasure to visit during two hours the vast installations and plants of this modern oil-refinery. These vast industrial plants and installations include more than 40 miles of roads and 9 miles of railway lines used by modern Diesel traction units. The refinery is the largest in Continental Western Europe.

The same day, another party of delegates went by special train and buses to Oosterbeek, near Arnhem, and had the opportunity of visiting the Kröller-Müller Museum, known for its remarkable paintings of masters from the XVth to the XVIIIth Centuries, as well as drawings and paintings from the Van Gogh collection. This party visited also the national park « De Hoge Veluwe ». Lunch was served to the delegates at Rijssenburg.

On Friday, June 8, an excursion to the Zuyderzee sponsored by the Minister of Transport and Waterstaat, and the Netherlands Railways, was organized in favour of the delegates and accompanying ladies.

The journey The Hague-Harderwijk was made by special train with the most modern types of carriages enabling therefore the delegates to appreciate the latest rolling stock of the Netherlands Railways.

Through the rich provinces of Central Holland and passing the historical towns of Leyde and Utrecht (Headquarters of the *Netherlands Railways*), the train arrived at Harderwijk, where buses waited for the delegates to take them to visit a new dyke near Lelystad, future capital of this new polder. There, a boat took the participants to visit the vast reclamation works.

The participants had the opportunity to admire the extensive works now in hand as well as the powerful dredging and pumping units in service. Their admiration went in particular to the spirit of enterprise and arduous work of the Netherlandish people in their century-old struggle against the sea. This impression was increased during the return journey when they saw the new polder areas already under cultivation, a beautiful countryside with modern farmhouses, pastures and orchards amongst new roads and canals.

The buses took the delegates back to Zwolle, where a special train was waiting for The Hague.

All these excursions perfectly organized by the Netherlandish Authorities will be long-living memories for the participants, who will never forget the charming hospitality enjoyed during their sojourn in the Netherlands.

Special mention must be made of the Ladies Committee, which under the management of Mrs. D.J. WANSINK and Mrs. E.L.C. SCHIFF, President of « The Hague Hotesses » did so kindly a great work to facilitate and render most pleasant the sojourn of the delegate's wives.

List of Members of the Permanent Commission

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(JUNE 4, 1956).

President :

M. **De Vos** (2), Directeur Général de la Société Nationale des Chemins de fer belges; 19, rue du Beau-Site, Bruxelles.

Vice-presidents :

J. **Goursat** (3), Directeur de la Région du Nord de la Société Nationale des Chemins de fer français; 18, rue de Dunkerque, Paris (X^{e});

M. **Crem** (3), Directeur du Service de l'Exploitation de la Société Nationale des Chemins de fer belges; 17, rue de Louvain, Bruxelles.

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Sir Gilmour **Jenkins** (1), Permanent Secretary, Ministry of Transport and Civil Aviation (Great Britain); Berkeley Square House, Berkeley Square, London, W. 1.

Ex-presidents of session, members ex-officio :

D^{r} Ing. G. **di Raimondo**, Directeur Général des Chemins de fer de l'Etat italien; Rome;

Ibrahim Fahmy **Kerim**; Le Caire;

D^{r} W. **Meile**, ancien Président de la Direction générale des Chemins de fer fédéraux suisses; Brügglerweg, 11, Berne;

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T.C. **Courtney** (2), Chairman of the Coras Iompair Eireann; Kingsbridge Station, Dublin;

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(1) Retires at the 17th session.
(2) Retires at the 18th session.
(3) Retires at the 19th session.

M. **Crem** (already named);

Csanadi (3), Directeur Général des Chemins de fer de l'Etat hongrois; Budapest;

Dr Ing. A. **Cuttica** (2), Vice-Directeur Général des Chemins de fer de l'Etat italien; Rome;

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Ibrahim Fahmy **Kerim** (already named);

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(1) Retires at the 17th session.
(2) Retires at the 18th session.
(3) Retires at the 19th session.

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(1) Retires at the 17th session.
(2) Retires at the 18th session.
(3) Retires at the 19th session.

SECRETARY'S OFFICE : 19, rue du Beau-Site, Brussels.

General Secretary : **P. Ghilain.**

FINAL SUMMARIES

adopted at the Enlarged Meeting of the Permanent Commission of the International Railway Congress Association.

(THE HAGUE-SCHEVENINGEN, June 1956.)

SECTIONS I AND III : WAY AND WORKS — WORKING.

QUESTION 1.

Research on the economic usefulness and the technical opportunity to install a third track, serving for common use (banalisation), in addition to sections of double track lines with heavy traffic, instead of installing two double track lines on such sections.

Consequences of the installation of a third track for use in either direction on the conditions necessary to insure the safety of train movements.

Summaries.

A. **Traffic considerations to be taken into account in the study of the various means available to increase the capacity of a double track line.**

« 1. — When on a double-track line « with a very heavy traffic, it becomes « necessary to contemplate increasing « the number of movements or of sub- « stantially improving the operating po- « sition, it is expedient at the outset to « study all the means of increasing the « efficiency of the two tracks in order « to take full advantage of the potential « offered by the line; for instance, im- « provement of the track lay-out in the « stations, provision at these stations of « interlocking installations, achieving « greater uniformity in speeds, provision « of automatic block signalling with « short sections, provision of complete « signalling schemes, two-way working « (banalisation) on one or both tracks of « the line.

« The efficiency of two-way working « requires that, at certain periods, the « density of the traffic in the two direc- « tions shall be unequal, either in res- « pect of the number of movements or « in the duration of line occupation; the « advantages are increased when traffic « peaks in one direction occur at the « periods marked by an almost complete « lull in traffic in the other direction.

« 2. — In the case where, owing to « the volume and characteristics of the « traffic, the above mentioned measures « would not offer a satisfactory solution, « it is necessary to examine from the « three view-points of traffic require- « ments, technical factors and economic « considerations, the value of adopting « one or the other of the following two « solutions : the construction of a third « track, or quadrupling.

« These two solutions have one factor « in common — one track reserved for

« each direction of movement, allowing « a same basic traffic; to compare the « two solutions, it is therefore necessary « to take into account the movements « it is considered desirable to transfer « from these tracks.

« 3. — In examining the movements « in the one direction over a heavily « used section of line, one can have « either a mixture of trains of widely « varying speeds, a situation characteris- « tic of the majority of railway routes, « or groups of trains at close intervals « in the same direction, which, indepen- « dent of differences in speed, occur at « the same time on the section. The « necessity for using the two tracks for « traffic in the same direction arises « from the fact that the number of trains « running in the peak periods exceeds « in time occupation the operating capa- « city of one track, after due allowance « has been made for the necessity of « not excessively sacrificing the running « of slow trains by holding them for « unduly long periods and at frequent « intervals.

« Variations in the speed of the trains « constitute an important factor in « requiring on certain sections of line « an increase in the number of tracks « to allow the overtaking, without stop- « ping, of slow trains by the faster « trains.

« 4. — Movements can comprise an « unbalanced pattern with peaks exceed- « ing the capacity of one track and « which occur always in one direction « only (either in a permanent direction « — up gradient for example — or in « opposite directions but at different « periods). In this situation the pro- « vision of a third track (respectively « without two-way working and with « two way working in the second) offers, « in principle, a satisfactory solution. « Overtaking without stopping is prac- « ticable in one direction only if the « third track is not equipped for two- « way working, or if it is so equipped, « it becomes practicable in the two « directions but at different moments of « time.

« On the contrary, if traffic peaks, « each exceeding the capacity of one « track, occur at the same time in both « directions of movement, quadrupling « is, in principle, the most likely solu- « tion. With this situation, a third track « in common user could be contem- « plated in certain circumstances and « with certain limits of traffic, but it « would be necessary to carry out on « this track true crossing movements as « on a single-track line.

« 5. — On any track used in one « direction only, the *theoretical track* « *capacity* is determined by the time « taken to pass through the longest « block section as measured in time. In « practice, the mixed nature of the traf- « fic (variations in speeds and in the « priority of trains) and out of schedule « running, as can always arise, make it « necessary to regard the *true capacity* « as being substantially below (average « value 0.7 to 0.8 of the theoretical « capacity); time losses occur in actual « traffic conditions through the need « to give second place to slow and less « important trains in relation to the « faster and more important trains using « the same track (cases of overtaking

« either as provided for in the timetable « or as necessitated by trains running « out of course).

« 6. — When a second track is « available in one direction, this permits « at least of doubling the initial capa- « city, and, by a careful allocation of « the fast and slow trains on the diffe- « rent tracks, it can even lead to a better « user of the two tracks considered « together.

« With a third track, the degree of « the increase in capacity is related to « the nature of the movements using the « third track; it varies according to « whether these consist either of groups « of trains in the one direction at close « intervals (the situation most favourable « to high capacity) or of numerous « movements in the two directions, « which in practice gives rise to the dif- « ficulties normally met with on single- « track lines. For this reason, the in- « crease in capacity with a third track « can only be measured in relation to « the different situations and then only « approximately.

« 7. — In regard to the actual use « of the tracks for a given traffic, qua- « drupling, in principle, allows of a « higher degree of specialisation, while « on a line with a third track, the neces- « sity to divert trains from one track « to another, according to circumstances, « and even contrary to the booked « working arrangements, is generally « more frequent.

« The necessity of diverting trains « from one track to another, and, in the « event, of undertaking on the track « equipped for two-way working true « crossing movements, as on a single- « track line, makes it essential above « all else to provide on the third track « a complete and rapid system of regu- « lating, which alone allows of substan- « tial flexibility in working, reflecting « itself in an increase in operating capa- « city. »

B. Examination of the characteristics of the facilities necessitated by traffic considerations.

« 8. — With the solution « qua- « drupling », the necessity of diverting « trains from one track to the other used « in the same direction being a less fre- « quent event, cross-overs will, in gene- « ral, be provided only at stations. In « the specific case of a section of line « with four tracks, where mixed working « according to circumstances over the « two tracks in the same direction has « to be provided for, it will be useful « to locate these tracks next to each « other and to install some additional « cross-overs between stations.

« 9. — With the solution « three « tracks », it is generally the view that « the centre track should be the one « equipped for common user as this « reduces to a minimum conflicting « movements. The third track placed « « outside » may be preferable in spe- « cific situations, when the slow trains « are on one and the same side of the « line in order that they can run along- « side the station facilities at interme- « diate points and to facilitate shunting « of the trains. In such a case it should « be possible in principle to run this « traffic on the third track alone, or

« with the use of the adjacent track for « one direction only.

« 10. — On a line with three tracks, « in so far as the diversion of trains « between the one-way tracks and the « track in common user (« voie bana- « lisée ») is concerned, it is necessary « to divide the track into independent « sections in such a way as to allow of « operation by sectional two-way work- « ing (« banalisation partielle »); it is « desirable for this purpose to install « between the one-way tracks and the « track in common user, connections « with a small angle of turn-out so as « to avoid the need for unduly severe « reductions in speed by the trains pas- « sing through them and to allow these « trains, if possible, to run through « them at the maximum speed permitted « on the less favourable of the two « tracks concerned.

« Sidings have to be installed where « it is necessary to consider holding « trains near the crossings and at con- « venient locations.

« At junctions where a direct connec- « tion to the track in common user « would give rise to fouling movements, « it will be usual to have recourse to a « fly-over or burrowing junction.

« 11. — As the cross-overs on the « track in common user constitute con- « verging junctions, it follows, as in all « similar cases, that both-way (bana- « lised) tracks should be provided with « a complete and clear signalling system, « and that the locomotives using these « tracks should be equipped with suit- « able devices such as cab-signals or « automatic train-control to ensure ab- « solute obedience of signals.

« 12. — Since it is particularly « necessary, in operating with three « tracks, to avoid all unnecessary loss of « time — whether it be in the selection « of the track to be used, in the deter- « mination of the crossing places, or in « the general regulating of the traffic — « automatic block signalling and centra- « lised traffic control (C.T.C.), capable « of effecting at the maximum speed « remote indication and control, are to « be recommended. This C.T.C. offers « the maximum operating advantages « when the dispatcher directly controls « the routes themselves and has the pos- « sibility of storing them.

« 13. — The regulating is again im- « proved by making available to the « dispatcher the most complete and up- « to-date apparatus, such as automatic « train describers (or automatic graph « recorders). The use of radio commu- « nication with the drivers of trains may « facilitate still further the task of the « dispatcher.

« 14. — In general, quadrupling can « be planned without C.T.C., as less « frequent intervention is then necessary « for train regulating purposes. »

C. Economic considerations.

« 15. — Three tracks, above all when « there is a two-way track in the centre, « can render necessary consequential « major alterations in the lay-out of the « existing tracks and signalling. These « alterations, in that they are carried out « on a line already conveying heavy « traffic, may result in an increase in the « cost of the scheme.

« On the other hand, quadrupling, or

« a third track laid outside, can be « planned and constructed, in certain « cases, with a minimum of alterations « and of difficulties on the double-track « line already in service.

« 16. — The ratios between the costs « for the installation of a third track and « for quadrupling naturally vary accord- « ing to local conditions. In the deter- « mination of these costs and their ra- « tios, it is necessary in the first place « to take into consideration, on the one « hand, local geographical conditions, « which according to circumstances will « make the quadrupling easy or diffi- « cult, and, on the other hand, the lay- « out more or less complex as the case « may be, at the stations to be adapted. « The ratio between these costs for the « two solutions, in the cases investigated, « varied from 0.6 to 0.85, but it could, « in exceptional situations, take values « outside these limits.

« 17. — In practice, the inter-depen- « dence of the many factors which are « involved in the efficiency and regul- « arity of the service makes it very dif- « ficult to give a precise estimate in « advance of the results to be expected « from one or the other of the two solu- « tions under examination. One me- « thod, for example, lies in establishing « graphically for each of the two solu- « tions theoretical timetables based on « traffic requirements and on the operat- « ing possibilities offered by the lay-out, « and then to compare the results ob- « tained, taking into account as far as « possible the ability of each to deal « with out-of-course working conditions.

« From this comparison, theoretical « data can be ascertained in respect of « the number of train-hours, and from « these calculated, with due allowance « for effective utilisation, the expen- « diture in terms of vehicle-days, the use « of motive power, train crews, etc.

« 18. — The economies in staff at « stations and in signalling are above all « related to the adoption of centralised « signal boxes at stations, of automatic « block signalling and of centralised « traffic control, with remote control of « points and signals. With this last « mentioned installation, which in cer- « tain cases allows of the achievement of « very substantial economies in staff at « stations and on signalling duties, it is, « however, necessary to take into consi- « deration the possible need to retain at « various points staff who can take the « requisite action when incidents of all « kinds occur.

« In general, the estimates in respect « of expenditure on staff at stations and « for signalling duties can only be esta- « blished in advance for the different « solutions examined, with a consider- « able degree of approximation.

« 19. — In regard to maintenance « expenditure on way and works, it is « equally possible to establish in ad- « vance estimates sufficiently accurate « for the two solutions — the provision « of a third track and quadrupling. It « will also be necessary to take into « account the expected requirements in « staff and equipment in the light of « the nature and arrangements of the « installations, and according to the « annual user of each track, expressed, « for example, in :

« total ton-kilometres / kilometre and train-kilometres / kilometre

« 20. — On the basis of operating « expenses determined as above and of « capital charges (interest and depreciation) it is possible to proceed to calculate the total annual expenses for « each of the two solutions contemplated, and finally to estimate in « approximate terms the expenses per « unit of movement and per unit of « traffic. »

D. Limits to the application of a third track in common user (triplement avec banalisation).

« 21. — The solution « three tracks », « which, in principle, is less costly than « quadrupling, can only be considered « if the traffic peaks present certain « clearly defined characteristics.

« Even if traffic conditions are in « favour of « tripling », the quadrupling « renders more easy the making of, and « adherence to timetables and ensures a « greater capacity advantages, which « would be likely to lead to it being « given preference from the operating « point of view, the more so if account « is taken of future needs.

« 22. — On lines carrying a very « heavy traffic the « third track in common user » may be preferred where « the cost of quadrupling is much higher « as is normally the case, particularly « where the configuration of the ground « is a factor. The most characteristic « examples are the following :

« *a*) common sections, near to large « towns, with high cost of land or major « civil engineering works necessary with « quadrupling; a case typical of sections « of line common to suburban and main « line traffic with peaks in one direction « only in the morning, at midday and « in the evening.

« *b*) short sections interposed between « four track sections, because of the « incidence of major engineering obstacles « too expensive to quadruple.

« 23. — In addition to the cases « cited, the provision of a third track, « with or without common user (according to circumstances) may be sufficient for traffic requirements on sections of line carrying traffic having « substantial differences in speed, sections where it is specially important « to allow overtaking without stopping « the trains.

« 24. — The fact that many Railways « only had for a long time an insufficient experience of the potentialities « offered by centralised traffic control, « both from the traffic and technical « points of view, can have led more « easily in the past, to neglect the solution « third track in common user ». « At present, in the light of technical « progress, the risk of a C.T.C. installation being put out of service accidentally is slight, and this cannot constitute a factor sufficient to reject this « solution.

« 25. — In the future, the provision « of a third track in common user will, « it seems, be adopted more frequently « than in the past even if its scope for « application to lines with very heavy « traffic remains limited in general to « relatively short sections with special « characteristics. »

SECTION II : LOCOMOTIVES AND ROLLING STOCK.

QUESTION 2.

In a system of standard, narrow or broad gauge lines which has Diesel traction for shunting and for main line working, what are the conditions governing :

1) the choice of the characteristics and kind of transmission;

2) the most economical organisation, maintenance and operation.

Research into savings that might be possible in comparison with steam traction.

Summaries.

« 1. — The formula according to « which the whole power is concentrated « in a single locomotive is that which « produces the lowest capital and main- « tenance costs. However, dividing up « the power required between two loco- « motives conduces to more flexible « working. Moreover, it is desirable to « do so at the present time whenever « the power required exceeds 2 500 HP.

« Multiple unit locomotives, which « can only be run as multiple units, « are now in use in the U.S.A.

« 2. — It is obviously advantageous « to reduce the number of classes of « locomotives. It is also advantageous « to provide standard equipment, com- « mon to several classes, at least in the « case of the auxiliary equipment.

« 3. — Under commercial transport « conditions as found in *Europe,* it is « difficult for any single class of loco- « motive to be suitable for hauling all « the different categories of trains. It « appears necessary to provide one class « of locomotive intended for fast or « heavy mixed traffic on the main lines « (1 500 to 2 500 HP or over), and one « or several classes of locomotives for « mixed traffic on the main and secon- « dary lines (750 to 1 500 HP) and for « the traffic on the secondary lines as « well as for shunting if necessary (less « than 750 HP).

« 4. — In the case of shunting, for « the different kinds of services, there « are three corresponding classes of « locomotive, the powers of which are :

« — for shunting in the small stations « and shops : less than 200 HP;

« — hump shunting and branch line « services : 350 to 600 HP;

« — heavy shunting and transferring « rakes : 600 to 800 HP.

« In some countries, these powers « may be exceeded. They largely are « in the U.S.A. where they may be as « much as 1 000 to 1 600 HP.

« 5. — The axle arrangement de- « pends upon the axle loads allowed by

« the track. In the case of the line « locomotives, the type AIA-AIA is « that most used on light track. The « BB and CC types are widely used on « standard gauge lines.

« Some of the railways on the Conti- « nent consider that the BB type is the « most economical up to 1 700 HP as « far as wear of the track and tyres is « concerned, whereas others prefer the « CC and even the IC-CI type.

« However, up to the present, insuf- « ficient data is available to determine « which axle arrangements gives the « greatest saving as regards permanent « way maintenance.

« In the case of locomotives of aver- « age power running at less than 60 km « (37 miles)/h, parallel axles from the « type B to the type D can be used. In « other cases, bogie locomotives are « preferable.

« 6. — Diesel engine technique can « now provide reliable and powerful « engines, and the tendency is to prefer « single-engined locomotives. However, « for special reasons (standardisation, » type of transmission) two-engined lo- « comotives may be preferred.

« When specially trained labour is « available, or can be trained to make « sure the maintenance work is properly « carried out, it is not considered advis- « able to sacrifice the efficiency of the « Diesel engine.

« On some Railways, where the « recruiting of trained labour for main- « tenance and the supply of spare parts « present a serious problem, it may « however be desirable to look into the « advisability of using a simple lower « efficiency Diesel engine of a well tried « type.

« 7. — In the U.S.A., the 2-stroke « engine is the more widely used; in « Europe the 4-stroke engine is more « generally used.

« However, several European Admi- « nistrations have put into service Diesel « locomotives fitted with two-stroke « engines. They are, however, not yet « in a position to make any statement « on the final balance sheet of the res- « pective advantages and drawbacks of « two and four-stroke engines.

« 8. — The provision of a single driv- « ing compartment permits a reduced « cost of construction. However, the « requirements of visibility may neces- « sitate the provision of a compartment « at each end.

« For this reason on locomotives « working train services the arrangement « with a compartment at each end « appears desirable. On shunting loco- « motives, however, the single compart- « ment is preferred. Certain Railways « state that this should be in the centre « of the locomotive and others at one « end.

« 9. — From the information receiv- « ed, it appears that in the majority of « cases mechanical transmissions are « used for relatively low powers; elec- « tric transmission for high powers.

« Hydraulic transmission competes « with the other two types at medium « powers. However, some satisfactory « arrangements of hydraulic transmis- « sion for higher powers have recently « been effected.

« 10. — Fitting a « dead man's device » is to be recommended on line « locomotives driven by one man. It « may also be of value when the locomotive has a crew of two men.

« Certain Administrations do not consider it necessary to fit this device on « shunting locomotives, even when they « are manned by only one person.

« 11. — The trains are heated either « by steam heating or electric heating, « according to the kind of equipment in « the rolling stock being hauled.

« In the case of steam heating — the « most widely used — the steam boiler « is preferably installed on the locomotive. Boiler-vans present a difficulty to the operating staff in many « cases such as terminals.

« 12. — Diesel locomotives can be « driven by one man.

« 13. — Diesel locomotives are capable of common user. They, therefore, permit the best use of locomotives and staff. It is an advantage for « the staff to be trained to drive the « different classes of locomotives and « railcars.

« 14. — In the case of secondary « lines, when possible, it is advantageous « to use the same locomotives for the « train services and for shunting operations in the stations involved.

« It may be of value to modify the « method of operating on certain lines, « both to improve the service and to « obtain a better user of the locomotives.

« 15. — It is possible to entrust the « driving of the small locomotives to « the station staff of the stations where « they are in use. This staff must then « be trained and supervised, and provision made for carrying out small « maintenance jobs on the spot.

« 16. — From the information supplied by the Administrations, it appears that in a general way, time of « service is about 20 %. Some Administrations, however, report lower « figures than this. So far as rates of « utilisation are concerned, which are « essentially dependent upon the services « in operation, they frequently reach « 60-70 %.

« 17. — Owing to the greater availability of the Diesel locomotive, it is « possible to work an identical service « with an appreciably smaller number « of locomotives with Diesel traction « than with steam traction. Compared « with the stock of steam locomotives « and so far as operating conditions « (traffic density, etc.) allow, the stock « of Diesel locomotives replacing them « is generally in the ratio of 0.6 to 0.8.

« 18. — The periods between the « different inspections and overhauls can « be determined either by the mileage « or the number of days or hours in « service. The mileage basis gives a « fairly close indication of the condition of the engine and the locomotive. « The time basis is more convenient to « follow for the maintenance services. « An intermediate method is to base the « inspections on the number of days or « hours in service and the overhauls « on the mileage.

« 19. — It is recommended that analyses of the lubricating oils and spec-

« tographical examinations of the ash « be made in order to obtain informa- « tion on the advisability of making an « oil change or carrying out preventive « repairs on some engine component.

« 20. — As with other methods of « traction, maintenance includes on the « one hand preventive inspections, and « on the other overhauls according to a « predetermined programme. Whether « this is based on « mileage » or « time », « there is a whole scale of inspections « corresponding to the amount of work « to be done. Between two general « overhauls of the locomotive, the « engine is given a part overhaul with- « out being dismantled.

« In most cases, the overhaul periods « laid down when the Diesels were « put into service would appear from « experience to be capable of being « increased. It appears that the most « economic maintenance policy is to « make high grade repairs at longer « intervals.

« 21. — Care must be taken to see « that the water used for cooling the « engine is neither corrosive nor scale- « forming.

« 22. — Provided certain rearrange- « ments are made, it is possible to make « use of the steam traction installations. « Such rearrangements affect the entry « and exit lines (installations of fuel, oil, « water and sand supplies) and the sid- « ings in the shed (making inspection « platforms, mobile hoods to draw off « the exhaust gases, etc.). In mixed « sheds, it is recommended that separate « installations be reserved for Diesel « traction.

« 23. — The stocking and supplying « of the fuel-oil requires at least two « tanks, one of which is a spare and « settling tank. Expressed in days of « average consumption, the total capa- « city of a distribution centre varies « between 20 and 40 days; the settling « period varies according to the quality « of the fuel-oil. There is a tendency « to give up centrifuging the fuel « and towards perfecting the filtering « methods.

« 24. — Since the Railway Admi- « nistrations find themselves obliged to « renew a certain proportion of their « stock of steam locomotives, it is na- « tural that they should change over to « a method of traction which shows « operating economies which are more « or less marked according to the type « of service, under the following three « headings : power, driving costs and « shed costs.

« *a*) As regards fuel, the economy « depends on the comparative cost of « coal and fuel-oil, including taxes. In « most cases, especially in the case of « shunting, very substantial economies « have been recorded.

« *b*) As regards driving staff, the eco- « nomies are considerable when only « one man is needed on the locomotive.

« Even in other cases, they are sub- « stantial, simply on account of the « better user of the staff.

« *c*) As regards shed costs, economies « of more than 40 % may be obtained.

« 25. — Economies under the head- « ing maintenance have been recorded « by some Administrations. It is too

« soon to express a definitive opinion on « this subject.

« 26. — Apart from strictly economic considerations, there are others, « such as the improvement of passenger « transport conditions, the improvement « of working conditions for the driving « and maintenance staff, and the greater « flexibility of working. In African « countries, doing away with the perennial problems of water and coal is an « appreciable advantage.

« 27. — At the present time, it is « difficult to assess the economic repercussions of dieselisation on departments of the railway other than « the Locomotive Running Department « (Motive Power). In particular, it is « not yet possible to say how the permanent way maintenance costs and « operating receipts will vary, all other « things remaining equal. The considerable reduction in the risk of fires « along the tracks can however be « mentioned.

« 28. — In general moreover, the « difficulty the Administrations have « found in presenting a complete economic balance sheet shows that it is « still too early for all the conclusions « on the economic aspects of dieselisation to be drawn. In an increasing « number of cases, however, economic « results of conversion appear favourable. »

SECTION IV : GENERAL.

QUESTION 3.

Development of railway tariffs.

Economic justification of these tariffs.

Adjustment of tariffs to the new conditions of the general economic system and to the competition of the other forms of transport.

Function of tariffs in coordination of inland transport.

Summaries.

« In order to achieve a sound distribution of traffic, both public and private, in accordance with the inherent qualities of each method of transport, the most suitable adaptation of railway tariffs to meet the new needs of the general economy, as well as the evolution and the competition of other forms of transport, is called upon to play a role of primary importance. With this object in view, the Enlarged Permanent Commission of the International Railway Congress Association have arrived at the following conclusions :

« 1. — It is essential that the policy of the States regarding the use to be made of railway transport should be defined within the framework of the general national transport policy.

« In this connection the permanent financial soundness of railway undertakings is an objective that must be achieved.

« 2. — It is desirable that, in so far as the railways are subject to competition from other methods of transport, they should in all matters receive equal treatment as far as possible.

« 3. — The obligations of every kind which have survived from the era of monopoly, to the extent that they cannot be cancelled, should be fairly compensated to the benefit of the railway undertakings.

« 4. — In any case, co-ordination of the different means of transport remains necessary. Co-ordination measures should be defined within the general transport policy but also taking into account their consequences upon the railways, as well as the special obligations of the latter as a public service and the fact that they cannot act on a strictly business basis like their competitors.

« 5. — The efforts made by the « railways to revise their tariffs, and « bring them in line with the actual « costs and market conditions should be « encouraged with the object of obtain- « ing a more rational distribution of « traffic between the different means « of transport.

« The flexibility required in the face « of competition should be authorised « and facilitated in relation naturally « with the factors of the specific costs « which must be taken into account.

« 6. — In the field of the tariffs, the « first objective should be first of all to « cover the costs separately in each of « the two sections « passenger » and « « freight ». »

[656 .257]

The operation of railway signalling installations,

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FIRST PART.

GENERAL.

I. **Stations.**

II. **Train movements.**

III. **Safety of the train movements.**

A. **General conditions.**

B. **Operation of points.**

1. *General.*
2. *Mechanical operation.*
3. *Electrical operation :*
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   b) *route levers;*
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C. **Point locking.**

1. *Methods of locking.*
2. *Control of locking.*
3. *Detection of the passage of a vehicle at a point or on a section of track.*
   A. *Track circuits.*
   B. *Speed relays.*
   C. *Treadles.*
4. *Control of the duration of locking.*

D. **Running on to lines over junctions.**

E. **Back shunts or setting back.**

1. *Back shunts in station.*
2. *Setting back on the running lines.*
   a) *Space between governed by time.*
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F. **Contrary movements on same section of track :**

1. *in stations,*
2. *on running lines.*

G. **Centralised control.**

FIRST PART.

GENERAL.

The object of the present report is to examine the electric operation of the signalling equipment in a station by a signal box of « all relays type » of an original conception and relatively cheap. Before however dealing with this subject, it will be useful to set out briefly the basic principles of signalling installations and to show how the new design signal box fits in with the other signal boxes.

I. STATIONS.

The signalling equipment of stations differ according to the traffic needs for

which they were designed : whether passenger or goods stations shunting, marshalling and holding yards, etc.

We will deal specially with passenger stations with heavy traffic for which the signal box considered in this report is perfectly suited.

On a railway system, there are many such stations and according to their importance and the particular traffic conditions can include the following installations :

— platform lines dealing with through trains either non-stop or with short stops for picking up and setting down passengers;

— other platform lines sufficient in number to receive the slow trains which have to make way for the faster trains;

— dead end platform lines forming a side bay to receive trains terminating on the station;

— various fans of relief or holding sidings for goods trains or to hold rakes of vehicles;

— service lines to handle with the least interference with the passenger traffic — the movements of the rakes of stock, locomotives, goods trains, etc.;

— lines for local goods services;

— turntables;

— miscellaneous shunting lines.

II. TRAIN MOVEMENTS.

The tracks in any station are connected to one another and to the running lines leading into the station by a complex of track equipment thanks to which the train movements required to deal with the traffic can be made.

There are two kinds of train movements :

1) movements of trains for sending on their way trains, rakes of stock, light locomotives coming from or going to neighbouring stations;

2) shunting movements which take place within the limits of the station for making up or breaking up trains. (Except for locomotives by themselves, these operations on the Belgian system are carried out under the supervision of a shunter).

If the train movements are to be made at a speed other than that when running under visual observation and with adequate safety, signals have to be installed to indicate to the train crews if they can run freely, if they should reduce speed or even if they have to stop.

The shape and aspect of the signals can differ as between railways without affecting the principles of working of the signal box. As regards the S.N.C.B. more particularly, five types of signals are in use :

1) those which, in the stop position, require all movements passing by the point they protect to come to a stop : stop signals;

2) those which show some distance away the position, stop or line clear of the stop signals so as to allow the train crews to bring the trains they are handling to a stand before the stop signal at danger : warning signals (distant signals);

3) those which, in the stop position, require shunting movements only to stop : shunt signals;

4) those which control the maximum speeds of the trains running over the section of line to which they apply : speed signals;

5) those which, when a train can proceed to several directions, give the driver the indication as to the direction he is to take : direction indicating signals.

Signals combining one or several of the functions defined by the types of signals given above exist. For example, a stop signal, a warning of the next stop signal which succeeds it and being able furthermore to give indications for shunting movements.

Formerly, the signal indications were given by means of arms or pallets or by round or square panels all moved by mechanical transmissions or electric motors. At the present time, there is an increasing tendency to give them by white or colour light signals and the signals are luminous by day and night.

These signals are simple in working, have much greater visibility than the mechanical signals especially by night and in fog and lend themselves particularly well to certain modern operating system such as the automatic block (1).

We will define « movement » in signalling as the run made by a train from one signal to another following it, naturally when the two signals considered have to be obeyed by the train in motion.

Example. — Movement of a train coming from a given direction, starting from the signal governing entrance to the station up to a platform line at the end of which there is another signal limiting the movement. If between the entry and the platform signal, there was a intermediate signal, the movement of the train except in two cases would give rise to two movements : one from the entry signal to the intermediate signal and the other from the intermediate signal to the platform signal.

The two exceptions are :

1) the intermediate signal is a shunting signal so designed that it never gives a stop indication for a train movement and the movement in question is precisely a train movement. This case occurs sometimes on the S.N.C.B.;

2) The intermediate signal is kept in the off position when the entry signal is taken off to let the train begin its movements. In this case, except it be out of order, the train always passes the intermediate signal and consequently it is considered to be a single movement. The case is met with regularly, for example when leaving a fan of sidings with one signal controlling starting from a number of tracks and a repeater at ground level for each siding. This latter can only be taken off if the starting signal properly speaking is itself in the « off » position.

It should be noted that the two signals limiting a movement are not always in the same station, for example, when despatching a train the movement usually begins at the departure signal at a station platform, and continues to the signal controlling the entry into the next station.

As regards the two extremities of a train movement the one the furthest from

(1) The present Belgian Railways colour light signalling has been described in the *Bulletin of the International Railway Congress Association,* for January 1949.

the station is known as the « direction end » and the other as the « end on the platform side ».

In the train movement envisaged above, when entering the station the entry signal then limits the « direction end » of the train movement. Should there be an intermediate signal to be obeyed, this signal limits the « end on the platform side » for the first train movement (entry signal towards the intermediate signal) and the « direction end » for the second train movement.

In the case of the departure of the train the « direction end » evidently is that of the running road the train takes to get to the entry signal of the next station.

We will call :

ENTRY, a train movement from some direction towards platform;

DEPARTURE, a train movement in the reserve direction;

shunting entry, a shunting movement from some direction towards a platform;

shunting departure, a shunting movement in the reverse direction;

line occupied entry (L. O.) the movement of a train into a line already occupied by a stationary rake of stock or train.

The motion of *direction* and of *platform* is most important if the operating and control systems to be described are to be understood.

III. SAFETY OF THE TRAIN MOVEMENTS.

A. General conditions.

A train or a rake of stock, before starting, should receive permission to do so from the signal box. This permission is given by the signal by which the train movement begins being taken off.

In the least perfected signal boxes, the taking off of the signals is simply subjected to the moral obligations of the signalman together with the records made in the appropriate books. The safety of the train movement depends then mainly on the vigilance of the signalman.

In the most up to date signal boxes, on the other hand, it is physically impossible to place a signal at clear until the conditions required for the safety of the train have been fulfilled. The few records made are solely to enable the running of the train to be followed and have no direct relationship with the safety of working, except in the case of the circuit controlling safety of operation getting out of order.

Between these two extremes, there is a range of signal boxes in which the safety devices vary considerably.

The extent to which safety devices are installed depends above all on the density of traffic on the lines served by the signal box. Progress on the working of the signal box consists in providing the equipment to deal with the maximum sets of conditions at the lowest cost, whilst simplifying to the limit the lever movements needed to control the train movements.

Before a train movement can be authorised, it is essential that the points to be run over are in the correct position.

Moreover, taking off the signal, is subjected to a whole series of conditions, imposed to prevent accidents the causes of which are inherent in the running of

the trains, that is to say, on the one hand derailments due to wrong movements of points, or on the other to collisions. Generally speaking, collisions result from on of the three following causes:—

1) run into by another train on points or at a junction;

2) overtaken by a following train on the same track;

3) trains running in opposite direction meeting head on.

These three causes therefore have to be examined together with the operating and locking of the points and crossings.

B. Operation of the points.

1. *General.*

The general expression of, « points », is used to describe all the appliances in the track used to enable a train to go from one track to another, turnouts, crossings, single or double slip-points. Fig. 1 gives the schematic representation adopted to illustrate these appliances and the possible train movements over each.

In a general way, points may be in either of two positions, right hand or left hand. The points are said to be right hand when for an observer placed before them they lead to a track to the right hand. The same points would be called left hand when for the same observer it would lead to a track to the left.

The points are operated either individually or linked together. One such linkage is formed of two pairs of points which during train movements can simultaneously take the same position to the right or the left. Fig. 2 represents diagrammatically linkage. For compatible movements AB and CD, the two sets of points lead to the right. To pass from A towards D the two points should be to the left.

2. *Mechanical operation.*

In signal boxes of minor importance, the points can be worked directly by the manual effort of the signalman on the levers. These levers are connected to the points either by wire transmission or rodding connected together by sleeves. The radius of action of such a « mechanical » box is limited to 200 to 300 m (218 to 328 yards) at most. It is impossible to operate from a single signal box of this type the points in a station of any size with heavy traffic.

3. *Electric operation.*

In this case, the points are operated electrically. In the field, the electric points operating machine is connected by suitable rodding to the two blades of the points. This machine carries out three functions :

1) to change the position of the points;

2) to lock the blade against the stock rail to ensure its immobility when vehicles pass over it;

3) to ensure that the distance between the locked blade and its check rail does not exceed 5 mm (3/16 in.) and that between the free blade and its check rail is large enough to let the train pass through the points without any risk of shock against the free blade.

(a) *Individual levers.*

To operate the points operating mechanism or possibly the two sets for

operating points in line, in some signal boxes there is a handle or lever with two positions, right or left, moving a spindle on the end of which there are the contacts for starting the motor of the machine on the line and on the other end

In this system, the pointsman sets therefore each point individually in the required position for the train movement to be made by operating the lever corresponding to the points. The box is described as one with individual levers.

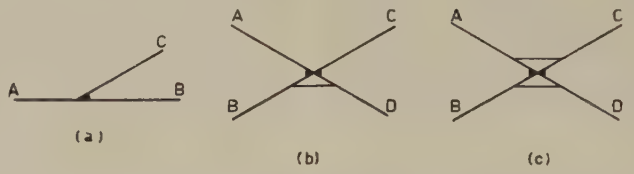


Fig. 1. — *a*) Simple points (possible movements : A-B, A-C);
b) Simple crossing (possible movements : A-D, B-C, B-D);
c) Double crossing (possible movements : A-C, A-D, B-C, B-D).

the contacts for controlling the position of the points lever in the electrical diagrams for working the signals.

The control of the locking of the blade against the stock rail and of the gauge relatively to their respective stock rails of the locked and free blades is registered in the signal box by a relay known as the control relay. This relay is excited when the optimum conditions of locking and gap are achieved. The stable position of a point out on the line is therefore demonstrated in the signal box on the one hand by the position of the points lever and on the other by the excitation of the control relay. (In certain control schemes two control relays are used one per possible stable position of the points.)

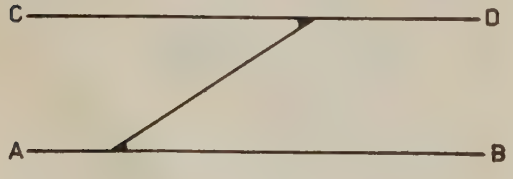


Fig. 2.

(b) *Route levers.*

A more advanced stage though more costly in the working of the points is that installed in signal boxes with route levers. In this type of signal box, the signalman no longer operates each lever individually. By moving one lever, the route lever, he puts in the correct position simultaneously all the points of the train movements to be prepared. Each point has its corresponding mechanical operating device capable of taking either of two positions and making the electric contacts needed to move the points. These parts are moved when the route levers are displaced through suitable mechanical linkage or pneumatically (air cylinders) or electrically (motors).

(c) *All relay box.*

A new stage in the simplification of the operation of points has been reached by the introduction of what are known as all relay signal boxes. In these signal boxes the mechanical operating gear has been replaced by relays. In this way,

it is easy to control together several points by means for example of a press button per movement. The whole of the operating and control relays for a set of points or even two sets in sequence forms the « *points group* ».

In Appendix II, as an example is given a description of the operation of the points in the all relay signal box, the object of this report (Appendix I contains the necessary explanation of the symbols used in the electrical diagrams).

The « points group » used for this operation consists of :

(*a*) a throw over relay with two stable positions (CAW). The inversion of the position of this relay controls the inversion of the position of the points in the track (or of the linked points);

(*b*) a control relay (KAW) whose excitation circuit controls in the track the locking and the position of the blades of the points;

(*c*) a differential relay (KTA) to reveal defects possibly occurring in the cables used for the working and controlling of the points in the track;

(*d*) a series relay (SAW) the object of which is to allow the use, in the cables connecting the points to the signal box, of the working lines as control lines after the operation of the points.

The method of operation described in the appendix is not peculiar to the signal box. Any other operating mechanism, which enabled the position of the points in an electric circuit to be defined, would be suitable. In the present case, this position is shown by a contact of the throw over relay (CAW) closed for a given position of this relay in series with a contact of the control relay (KAW).

C. Immobilisation of the points operating gear.

When the points are in the correct position for the train movement to take place, it is necessary first of all to prevent any irregular movement of the points. With this object in view, the operating gear will be locked, its locking checked, before the signal authorising the train movements is taken off. This locking shall be effective as long as the train has not wholly passed over the points.

We will deal with in turn :

1) the method of locking the points operating gear;

2) the control of the locking of the points in the required position;

3) the methods used to detect the passage of a vehicle at any place or on a given section of track;

4) the use of these methods to control the period of immobilisation of the points operating gear.

1° *Means by which the points operating gear can be held fixed.*

A. *In mechanical or individual lever or route lever signal boxes,* this is obtained, in principle, in two ways which can be combined.

(a) *Lock.*

Each mechanical part of the operating gear can be held fast by means of an electric lock. This lock consists essentially of a relay operating a latch. In the disexcited position, the latch falls into a slot cut in a slide or cam forming part of the mechanical operating gear of the points to be held fast. To release the points, the relay of the lock must be excited.

(b) *Locking table.*

The mechanical locking of the points can be achieved by means of an interlocking table. In this case, there are mechanical connections by means of wedges between the various mechanical parts of the gear operating the points and the route levers or the levers to take off the signals. These connections are so made that the levers can only be reversed if each points operating gear is in the correct position for making the movement. Once reversed these levers are locked by electric lock.

B. In the *all relay signal boxes,* all that is needed to lock the operating gear of a point is to prevent any current from flowing to the operating relay in question. With this object, we can for example attach to each point or even better to each group of points the operating gear of which can be locked together without inconvenience, a locking relay IR which in the excited position allows the operating relays to be worked and in the disexcited position prevents any current from arriving at the same relays.

It is to be noted that a point is free when its locking relay is excited. If then for any reason (insulation, blowing of a fuse, etc.) the locking relay is disexcited the operating gear of the points would be prevented from moving. Any derangement therefore is in the direction of safety.

2° *Checking the locking of the points operating mechanism.*

Locking the points operating gear is not sufficient in itself. It is essential to know that in the open track the points are indeed in the position necessary for the train movement to be made.

A. In the signal boxes without mechanical locking, an electric circuit is used in which each set of points is represented by the elements which show with certainty its position in the track. The electric circuit is so laid out that when the sets of points are in the required position for a movement to be carried out, a relay which checks the setting up of the route is excited. This relay which may also check other conditions than the position of the points has to be energised to allow the signal authorising the movement to be placed at clear.

B. In signal boxes with mechanical interlocking tables, a check is already provided in the mechanical interlockings. This control simply registers the position of the points levers in the box but does not show certitude if the points out on the line have obeyed the levers, for this reason for complete safety it ought to be doubled by an electric control circuit similar to that used with signal boxes without mechanical interlocking.

3° *Detection of the passage of a vehicle past a point or over a section of line.*

To register a train movement past a point or over a given section, three methods are available namely, track circuits, insulated rails, or treadles.

A. *Track circuits.*

A track circuit (fig. 3) is formed by a section of track between insulated fishplates intended to stop the propagation of the electric current (fibre, wood, moulded materials, or metal fishplates

with insulated bushes). Two rails inside this section have their ends connected by copper bonds or iron wires welded or rivetted at the rail ends. These bonds assure the electrical continuity of the track normally inadequate owing to the rust always found between the fishplates and the rails. At one end of the insulated section a supply of current is connected in series with a regulating device and a protection device (resistance and possibly condenser). At the other end of the section a suitable relay known as a track relay is provided.

When there is no train on the section, the track relay receives current from the supply through the two files of rails, which play the role of two ordinary electric circuit conductors. Provided the characteristics of the current supply of the regulators and of the track circuit have been properly selected and if, in addition, the track is well ballasted, the track relay is energised whilst there is no vehicle on the insulated section. Contrarily, as soon as a train runs on to the section and as long as a pair of wheels remains on it, the track circuit becomes de-energised as a result of the short circuit caused by the pair of wheels and axle. The short circuit by an axle is not complete. It varies from axle to axle. Moreover the two files of rails are not perfectly insulated between themselves and the earth : their insulation depends upon local circumstances. Consequently, it is always necessary to regulate the track circuit.

B. *Insulated rails.*

In principle, the insulated rails are short track circuits with only one rail insulated and rarely exceed 50 m (54 yards) in length. The insulated rails can be used with simpler and cheaper equipment than when track circuiting is used.

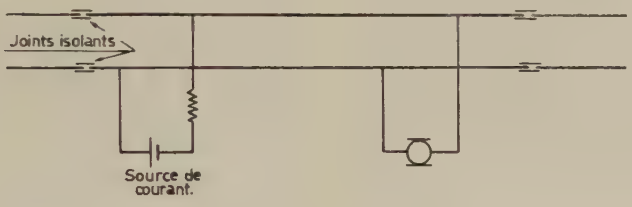


Fig. 3.

N. B. — Joints isolants = insulating joints. — Source de courant = current supply.

C. *Treadles.*

With track circuits and insulated rails, it is possible to check that no vehicle is on the section of track corresponding to an insulated zone. The treadles or rail contacts, on the other hand, record the passage of a vehicle by a given point.

A treadle is arranged that when at rest it makes or breaks a contact which inversely breaks or makes when the pedal is depressed by the wheels of a vehicle.

There is a great variety of treadles in use. The one in general use on the Belgian Railways (fig. 4) is composed, in principle, of a fitting in the form of a bowl suspended from the foot of the rail between two of the sleepers. The fitting carries a reservoir filled with mercury up to a diaphragm

which closes it. The reservoir is connected by a pipe to a bowl in which is secured an insulated pointer connected to an external conductor. So long as no vehicle presses down the treadle the mercury does not reach the bowl. The working of the treadle is due to the deflection of the rail when the wheels of a vehicle run over it. The increase in the curvature of the rail drives down a plunger which exerts pressure on the diaphragm and consequently on the mercury in the reservoir. The mercury flows through the pipe into the small bowl coupled to the reservoir and makes an electric contact between the insulated pointer and the earth of the treadle frame. Once the train has passed, the mercury runs back out of the bowl and the previously made contact breaks.

The treadle just described therefore has its contact cut when at rest. It is used for example in combination with an insulated rail (fig. 5). At the site selected for recording the passage of a train, a section of track 18 m (19 yards) or more has one file of rails insulated whilst a rail contact is attached to the other file of rails (earth rail). The rail contact plays its part in the layout of the first treadle relay (RPV) and the insulated rail in that of the second relay (V). The contacts A and B (fig. 5) are contacts of route levers of locking relays of points operating gear or of any other device registering the setting up of a train movement via the treadle. As soon as a movement is set up these contacts close.

The insulated rail being free, the second treadle relay is energised whilst the first remains de-energised. The moment the train comes on to the insulated rail the second relay drops. When a short interval of time afterwards, the train reaches the treadle, the first relay energises and remains excited by one of its own contacts. Then on the train clearing the insulated rail completely, the second relay is energised as well. The treadle has « unlocked » and the two treadle relays remain energised until the moment the set up of the train movement is cancelled.

4° *Verification of the duration of immobilisation of the points.*

We will only consider the case of stations with modern signalling boxes leaving the signalman under normal conditions the minimum of responsibility as to the safety of the train movement.

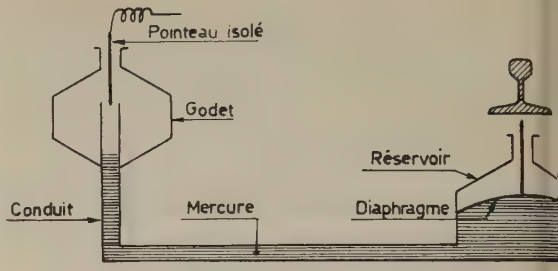


Fig. 4.

N. B. — Pointeau isolé = insulated pointer. — Godet = bowl. — Conduit = pipe. — Mercure = mercury. Diaphragme = diaphragm.

The problem can be reduced to the determination of the beginning and the end of the period during which the points are locked into position.

The blocking of the points can without adversely affecting the safety of the train movement begin at four different instants :

1) immediately after the train movement is set up;

2) on the signal authorising the movement being taken off;

3) at the moment when, the signal being off, the train runs on to an

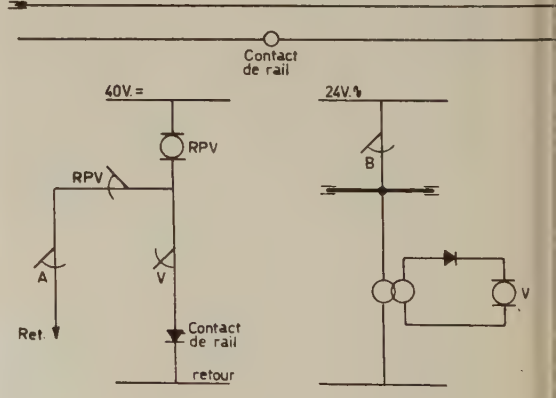


Fig. 5.

N. B. — Contact de rail = rail contact. — Retour = return.

insulated zone known as the signal approach zone. It begins in line with the signal post and continues before it for a sufficient length to prevent the movement set up being cancelled before the driver of one approaching train has been able to perceive the warning of the protecting signal in the off position. The approach generally is carried out only when it is a question of a box operating the apparatus of a zone equipped with automatic block;

4) At the moment the train begins the movement. In this last case, the signalman who takes off the signal authorising a movement has the means for restoring the signal to danger, to cancel the route set up and if needed to alter the points so long as the train has not passed the signal authorising the train movement. This case then can only apply to movements made by trains always stopping before so doing (shunts, departure from local lines, etc.). This possibility given to the signalman always involves some danger as the driver of the train can have seen the signal authorising the movement in the off position and not have noticed until at the last moment that the signalman has returned it to on.

Locking the signal in the off position has the obvious advantage of greater flexibility as compared with locking the train movement set up. Frequently, the points are provisionally locked on the train movement being set up and this is made definite when the signal is taken off. The provisional locking can be released at any time by the signalman. The definite locking can only be effaced by the train or in case of failure by breaking the seals of the safety appliances. This arrangement is reflected in practice by various devices according to the type of signal box : electric locking of the route levers or point levers, points locking relays, etc. Locking the points by these devices is sometimes given the name of « transit ». The moment the points become free depends essentially on the means used to carry out the « transit ». There are two main types of « transit » : the rigid transit and the flexible transit.

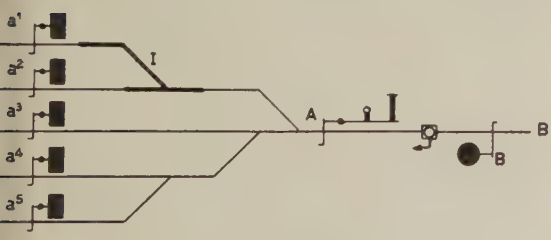


Fig. 6.

With the rigid transit, the train movement is divided into several sections limited by treadles combined with insulated rails. The points included in one section are locked and released together. They are freed at the moment that the train has run over the section and completely cleared the treadle placed at the leaving end (end of section treadle or section leaving pedal). At this moment, the locking of the route levers or points levers or the locking relays thereof are again energised.

The rigid « transit » provides perfect safety, but its rigidity can be a hindrance especially in the case of signal boxes carrying out much shunting. Let us take for example (fig. 6) a fan of sidings the neck of which is fairly long. To effect an exchange of wagons from siding 1 to siding 2, it is necessary with the

rigid « transit », starting from the ground signal a^1 repeating signal A to make a shunt in this direction B so that the rake will clear completely treadle B. After this starting from signal B, it is necessary to back shunt towards siding 2. It would have been quicker starting from siding 1 to pass over the points leading into siding 2, to alter its position, and then set back immediately and without any signal towards siding 2. With the « flexible » transit such a movement can be carried out. In this case, the station is divided into insulated sections or zones. Each zone has its corresponding insulated rail relay and one or several locking relays for the points in the zone. The locking of the points in the blocked position becomes effective at one of the moments defined above. In order that the points in an insulated zone over which a train movement is being made may be liberated anew, the essential requirements are :

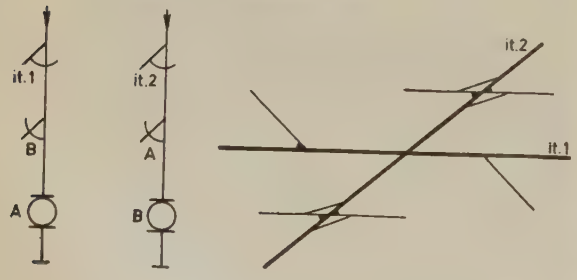


Fig. 7.

1) the signal authorising the movement must be on;

2) all the insulated zones between the starting point of the route and the « transit » zone considered must be free.

In the case of an exchange between adjacent sidings of a fan of sidings as considered above, the procedure followed will be : the movement is set up from siding 1 in the direction of B at the latest when the zone is entered by the movement, the points of the movement set up are all blocked into position.

As soon as zone 1 is cleared by the rake, the points leading to siding 2 are released, and after these points have been set by the signalman, the train is set back towards siding 2. When the rake has cleared all the insulated zones between 2 and B, all the points in this zone are liberated.

The « flexible transit » is but rarely used on the Belgian system. The « rigid transit » is preferred generally : it is less costly as the insulation of the whole is not necessary and it provides greater safety.

D. Side or glancing collisions.

Two movements cut one another either at points or on a crossing. In the first case, the process of locking the points described above eliminates all risk of glancing collisions. In the second case, for example provision could be made for two « incompatible » relays A and B (fig. 7) mutually controlling each other and one of which ought to be energised if the movement runs on to the crossing on a given branch whereas the other serves the other branch. In signal boxes with interlocking tables it would also be possible to introduce interlocking between levers of incompatible routes.

E. Overtaking trains.

Overtaking on the installations of the station itself will be dealt with separately from the case of overtaking the line between two stations.

I. *Overtaking or running into a train in a station.*

When a train makes a movement in a station the devices for locking the points described above make it easy to prevent the train being run into by another. All that is needed is to forbid the taking off of the signal authorising a movement so long as the preceding train has not cleared completely either the insulated zones covering the whole journey or an electric treadle or any other equivalent combination installed at the end of the route run over by the train. Moreover it is also necessary to restore to danger sufficiently early the signal authorising the movement so as to prevent a second train from following the same movement thanks to the signal taken off for the first train. In modern signal boxes the signal is returned to stop automatically by the train. This is arranged by cutting the electric circuit which allows the signal to be taken off as soon as the train runs in the insulated zone marking the beginning of the movement, or as soon as the train has completely passed over the treadle at the start of the movement. In the first case, the signal goes to stop « at the first pair of wheels » : in the second, it goes to stop « at the last pair of wheels ». The method with the signal going to stop after the last pair of wheels has passed is better for movements made with the locomotive in the rear of the train as the driver sees the signal off before him so long as he has not passed it.

It is not enough to provide for the signal going to danger, it is essential to be sure it does. When the signal goes to danger through the de-energising of a relay known as a « safety relay », the design of which is such that it cannot remain without current accidentally in the energised position, no special precautions are called for. In the case in which ordinary relays are used, at lower cost, before a movement passing a signal can be authorised, it is necessary to check the signal has gone to danger after the previous movement.

In the case of a train entering a platform line or a line in a fan of sidings, the treadle controlling the end of the route, or alternatively the last insulated zone of the train movement obviously does not cover the section of line beyond the last set of points the train passes. In fact, the train entering this section of line can remain there a long time and it would be wrong to put out of use for such a reason one or a number of points in the station. To avoid any question of a train overtaking a previous one all that is needed is to insulate the piece of line on which the train is standing. Normal entry on to this section is allowed if the track circuit gives clear. If, on the other hand, the track circuit shows line occupied any entry into the section is forbidden, or if it has to be allowed it may be permitted by giving at the signal at the entry into the section an indication of « line occupied ». When there is no track circuit, the distinction as to line free or line occupied is left to the care of the signalman.

II. *Overtaking on the open line.*

When a train leaves a station to go towards another, the train movement it makes has as its final point a signal not as a rule any longer dependent upon the

departure station. The method of protection against running into a train in a station, described above, is efficacious up to the last set of points the train movement affects. Beyond these points, protection has to be made certain by other means. The trains must be spaced out along the line.

(a) *Train spacing by time intervals.*

Originally the spacing was done by maintaining a certain interval of time — usually ten minutes — between two train departures or the passing of two consecutive trains. This method has obvious drawbacks due to differences of speed between two following trains, or to breakdown possibly occurring to a train on the stretch of line between two stations, etc. The railways had therefore to fall back on another method by which the number of trains run could be increased with safety : this is the method of spacing by distance known also as the block system, or section working.

(b) *Train spacing by distance.*

The line is divided into sections either one or several between two successive stations according to the distance they are apart and the density of the traffic. A block signal at the beginning prevents any train entering the section so long as it has not been cleared by the last train which entered it. When immediately after receiving the indication « line clear », the signal is taken off by the signalman the block system is known as the open or released block system. If the signal is taken off automatically the block system is said to be the automatic block system. If on the other hand, the block signal is only taken off when another train ought to enter the section, the system is known as the block system with closed blocks.

The control of « section free » can be carried out in different ways :

1) *by communication equipment without interlocking (telegraph, telephone).*

In this case the whole safety depends upon the correct carrying out of all operations by the signalman. He will make sure he does not allow a train into a section without making certain beforehand he has received permission from the next station in front.

Communcations between posts on the subject have to be entered on the block book in accordance with the regulations;

2) *by communication equipment interlocked* with the block signal.

With the object of preventing wrong movements by the signalmen the railways have been led to providing on the block signalling instruments which deal with certain of the prescribed regulations. These interlocking devices are almost always electric and there are a number of designs in existence.

Let us briefly review the conditions as materialised in current use by the Belgian block system :

(*a*) to take a block signal off, the authorisation from the station ahead or transmitting station must have been received. This is done by means of an electric circuit between the two signal boxes. Once the authorisation transmitted is received the entry signal is « unlocked » and can be taken off :

(*b*) the station ahead cannot transmit an authorisation unless the preceding train has actually cleared the section. This condition is controlled by the train passing a treadle placed in the track at the outgoing end of the section. So long as this treadle has not been operated by the previous train the signal box ahead is unable to transmit an authority to proceed;

(*c*) when transmitting an authorisation a check is made to make sure the signal at the end of the section has indeed been restored to danger by the preceding train;

(*d*) the authorisation given by the signal box ahead to the signal box behind does not permit the latter to take off his signal more than once as otherwise two trains might run into the same section. This « monokinematic » condition is ensured either mechanically or electrically.

3) *by track circuits.*

The conditions fulfilled by the block system with treadles just described do not cover all those the signalman has to obey. It may happen that through a broken coupling part of a train may remain unprotected after the first part has cleared the section should the signalman not have satisfied himself that he has seen that the end of the train has cleared the signal.

To cover this condition, practically continuous track circuiting over the whole section would have to be used and the presence of trains in the section be controlled permanently.

In the manual block with track circuiting, also known as the automatic block, the authorisation transmitted by the signal box ahead only checks that the leaving signal of the section has gone to danger. If this latter signal is a colour light signal and is automatically placed at danger by a safety relay this control becomes unnecessary. Before the signal box in rear can send a train into the section all that is needed is to let the signal covering the entry into the section to be taken off as soon as the track circuit of the section is clear.

In certain special cases, the track circuits have been replaced by other methods of equivalent value such as axle counters.

When the block sections are formed of the running line, the introduction of continuous track circuiting dispenses with all manual operation of signals and replaces it by purely automatic working. This very simple system gives the maximum guarantee of safety as it subordinates the resetting of the block system to clear to the section having been completely liberated. Then too, being automatic it is faster than the manual block, a valued advantage on heavy traffic lines. The automatic block system is almost always used in conjunction with colour light signals.

(c) *Entry into an occupied section.*

When a train comes to a signal controlling the entry into a section at danger, the section very probably is occupied. Nonetheless, it may be that the signal cannot be taken off through some mechanical or electrical defect.

Two extreme solutions can be considered. It could be decided that no

train can ever enter an occupied section. This would be the absolute block. On the other hand, it could be laid down that a train can always run past a block signal at danger and enter an occupied section provided it runs on sight, that is at such a speed that taking into account its brake power, the line gradient, and visibility, that the train can be stopped without doubt before overtaking the preceding train. This is the permissive block.

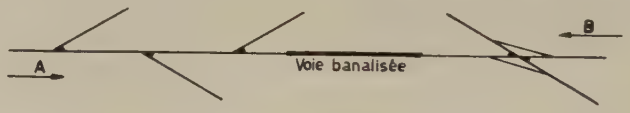


Fig. 8.
N. B. — Voie banalisée = track in common user.

Actually, the block system is never completely absolute or permissive. The absolute block rules are tempered by letting a train to run on sight into an occupied section by giving the driver a permit to pass the signal issued by an authorised member of the staff (Assistant Stationmaster or signalman according to circumstances). In the case of the permissive block, the train has to be brought to a stand before the permissive signal before continuing on sight. In the case of the Belgian Railways, the engineman during this stop has to take out a ticket provided for this purpose from a container on the signal post. The permissive block is almost indispensable in the case of lines equipped with the automatic block system.

In all cases, we consider it desirable that a train stopped in a section should be readily seen. This brings out the importance of the tail lights on trains whether a single or several red lights. These signal lamps must be properly looked after and located.

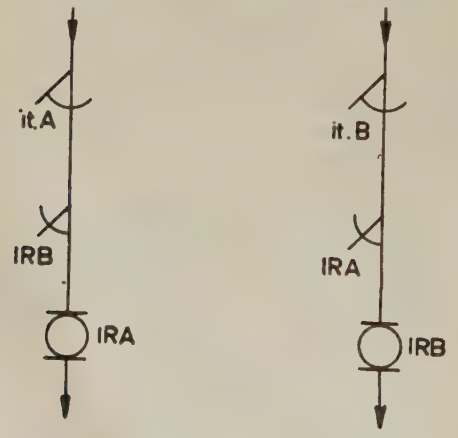


Fig. 9.

F. Collisions.

As in the case of a train running into another, we will differentiate between collisions on the running lines and those in stations.

I. *Collisions in stations.*

Collisions may result by trains coming from different directions such as A & B for example and ending in a common section of line (fig. 8).

There are two cases to be considered :

(a) *The directions A & B are operated from the same signal box.*

The common section of track will be fitted with two incompatible relays IRA

and IRB (fig. 9). These two relays check one another. When a movement from A is set up, the relay IRA is energised and a check is made to see that relay IRB is de-energised. The relay IRA will remain energised during the whole time the movement from A lasts.

The exact opposite will be done for a movement from B.

(b) *The directions A & B depend upon different signal boxes.*

For example, the direction A from signal box A and direction B from signal box B. In this case, a signal authorising a train movement from A requires the authorisation or « slot » of signal box B and vice versa.

There are a number of types of slots. Some are solely by telephone : others, on the other hand, are of more advance design and are translated into practice by energising at the signal box requiring the slot a receiving relay. This relay is in the circuits authorising the taking off of the signal.

II. *Collision on running roads.*

These can occur on single lines or on double track lines, when train movements in the wrong direction are allowed.

The regulations for safety on single lines can be classified into two quite distinct groups :

1) in the first, as a principle, the trains must obey a working got out beforehand in the timetables and which shows at least the stations where each train has to cross another;

2) in the second, on the contrary, the trains from a safety aspect may not have passing points specified in advance. In order that a train can run into a section between two stations A & B all that is needed is for the section to be clear.

The assurance that the section is clear can be obtained :

(*a*) by exchanging telephone messages between the stations A and B, together with their recording in suitable books and according to the degree of perfection of the system by operating the block instruments, exactly as in the case of the block-system on double track lines.

The automatic block system enables the problem of the single lines to be solved in a most satisfactory way. Basically, there are a signal box at the entry and a signal box at the leaving end of the section of single line between two stations at which trains cross. In order to reverse the direction of running on the single line, the exit signal box asks the entry box for permission. When transmitting the permission, the liberation of the section of single track is checked. Furthermore, as a result of this permission having been transmitted the signal box at the beginning of the section is materially unable to give access to the single line considered The direction of running is therefore reversed and the signal box, formerly the entry signal box becomes the leaving box and vice versa. The space between trains running the same way is ensured by the automatic block signals;

(*b*) *by piloting.* Each train is accompanied by an employee called a pilot. When several trains in the same direction follow one another the last is the one on which the pilot travels.

G. Centralised operation.

Theoretically an electrified signal box enables the points and signals at any distance to be operated. It must not be overlooked however that each point, each signal, each outside signalling device is connected to the signal box by control and operating circuits. Consequently, the radius of action of a signal box is limited by the cost of cabling, which rises rapidly if it is necessary to operate at great distances (over 1 500 m [1 640 yards] for example) an important number of appliances. When such cases present themselves, it is better to use layouts in which there are no particular circuits for each appliance to be operated but, instead, to use a single line for the operating and for the checking of the various appliances.

The common feature of these centralised operating arrangements is that at the centre of the group to be operated a satellite box is set up with the operating locking and checking relays of the appliances in the group. The cabling of the satellite box is not costly as the appliances to be operated are not far away. The energisation of the various operating relays in the satellite box is done from the main signal box by sending over a two or three wire conductor, a single conductor for all the appliance to be operated, a code of operation provided by a train of impulses obtained in a similar way to those used with automatic telephone. The line is also used to send by the relays of the satellite box a code of control whereby the signalman in the main box can follow the working of the apparatus in the satellite box.

The safety provided by the centralised operation is exactly the same as with direct operation. Actually, the apparatus forming the centralised operating gear has never anything to do with safety. This safety is assured on the satellite box by circuits identical with those used in a signal box operating directly of the all relay type.

APPENDIX I.

Representation of the relays and identification of their contacts in the signalling diagram.

We use in the present report symbols adopted by the S. N. C. B. to represent the relays and their contacts

a) The windings of the relays are represented by simple conventional signs.

In principe the symbole ⊏⊐ represents a winding of an ordinary direct current relay and ⊠ a winding of an ordinary alternating current relay. If the sign ⊏⊐ is replace by the sign □, the relay is a « safety » one. A safety relay has such mechanical constructive characteristics that without current it cannot accidentally remain in the energised position.

The de-energisation of this relay consequently ought not to be controlled whereas generally an ordinary relay is controlled if at least it fills a role of safety in the schemes.

The symbols ⊏⊐ or □ designate windings of relays with delayed drop. Such relays hold themselves in the attracted position a short instant (0.2 to 0.5 sec) after cutting the current feeding their winding.

b) The functions of the relays are designated in abbreviated form by one or several letters. The accompanying table shows most of the abbreviations met with in the schemes of this report.

c) In all the circuits, the contacts of the relays are shown under the hypothesis

that the relays are de-energised even if these relays normally are attracted.

A relay is said to be energised or attracted or in the top position or even in the working position when its winding has a current passed through it sufficiently to attract its armature. In the contrary case, the relay is de-energised or in the down position or in the position of rest.

The symbol designates a simple relay contact which when the relay is de-energised prevents current from passing through an electric circuit. The contact is said to be normally open.

The symbol designates, on the contrary, a simple contact which under the same condition lets current pass. The contact is normally closed.

The symbol designates a switch of relay which when the relay is de-energised lets a current pass from C towards A but breaks the current from C to B.

The symbol designates a switch which does not interrupt the current.

When the relay is de-energised, the current flows from C towards A. When on the contrary, the relay is energised the current flows from C towards B. Nevertheless, contrarily to what happens with an ordinary relay switch, the change over of the current from A towards B takes place without break, that is to say the current from C towards B is established before those from C towards A is interrupted.

Two simple relay contacts used conjointly and represented by and are such when the relay is energised the current passing from A towards B is not broken before the current from C towards D is flowing.

d) Case of the throw over relay.

A throw over relay usually has two plug boxes one the positive and the other the negative. This relay has two stable positions : in one (position +) the armature of the mobile contacts of the positive plug box is in the top position and that of those of the negative plug box is in the down position. In the other position (—), the reverse is the case. To pass from the first stable position to the second a current of sufficient strength must be sent through the negative winding of the throw over relay, the positive winding being without current. Reciprocally, the pass from the second stable position to the first, a current of sufficient strength must be produced in the positive winding of the throw-over relay with the negative winding without current.

The symbol designates a normally open contact of the positive plug box, this being in the down position.

The symbol designates a normally closed contact of the same plug box in the same condition.

The symbols designate the same thing for the positive plug box.

When the throw over relay is a points operating one, this relay is in the position + when the points are to the right and — when to the left.

e) Case of the keys.

The key contacts are shown as the relay ones with a distinctive sign which varies according as it relates to :

1° a key automatically restored to the rest position :

contact normally open in the rest position;

contact normally closed in the rest position;

2° a key with two stable positions :

contact normally open in the position of the key considered on the rest position;

contact normally closed in the same position;

3° a key either sealed or fitted with a recording counter :

contact normally opened in the position of the key considered as the rest position;

contact normaly closed in the same conditions.

f) In the circuits, the symbol of the contact or of the key also bears an inscription which includes the abbreviation of the function of the relay or of the key followed by a sign which marks the character of the relay or key amongst the relays or keys of identical function.

Example :

signifies : contact normally open of the + plug of the relay for operating the points 1.

In the all relay signalbox described in this report, the route operating relay is very frequently used. This is why its representation has been simplified. The abbreviation of the function of the relay has been suppressed.

Example :

signifies : contact normally open of the route operating relay from A to I.

The same applies to the route setting keys.

Example :

signifies : contact normally open of the route setting up relay from A towards I.

Designation of the relays or keys.	*Origin of the abbreviation.*	*Abbreviation.*
1. Series relay of the group of points.	Series. - Points. - Wissel.	SAW
2. Differential relay of the group of points.	Control. - Land. - Aarde.	KTA
3. Points operating relay.	Operation. - Points. - Wissel.	CAW
4. Points control relay.	Control. - Points. - Wissel.	KAW
5. Route operating relay.	Operation. - Route.	CR
6. Route or transit locking relay.	Locking. - Route.	IR
7. Movement selector relay.	Selector.	S
8. Monocinematic relay.	Monocinematic.	M
9. Coupling relay.	Control. - Route.	KR
10. Control of signal at stop relay.	Control. - Closure. - Signal.	KFS
11. Control of signal at clear relay for train movements.	Operation. - Signal. - Permission.	CSA
12. Control of signal at clear relay for shunting movements.	Operation. - Shunt. - Rangering.	CMR
13. First treadle relay.	Recording. - Passage. - Voorbij.	RPV
14. Second treadle relay or insulated rail relay or track circuit relay.	Track.	V
15. Slot receiver relay.	Receiver. - Ontvanger. - Slot.	ROS
16. Incompatible movement relay.	Locking. - Route. - A.	IRA
	Locking - Route B.	IRB
17. Approach zone relay.	Zone. - Approach. - Nadering.	ZAN
18. Emergency closing key.	Stop. - Dg.	SDG
19. Route cancellation key.	Cancellation. - Route.	NR
20. Locking cancellation key.	Cancellation. - Locking.	NI
21. Track circuit control cancellation key.	Cancellation. - Track.	NV
22. Treadle cancellation key.	Cancellation. - Treadle.	NP
23. Enquiry key or relay of the optical control table.	Duplication. - Press button. - Knop.	DPK

APPENDIX II.

Points operation.

The method of operation in the all relay signal box described in this report is based on that in use on the Belgian railway system in the signal boxes with individual levers or with route levers. The levers of the points and their contacts have been replaced by throw over relays with two stable positions and two energising windings. To turn over a throw over relay all that is needed is to pass a strong enough current through the respective energisation winding. If both windings be excited at the same time the relay does not alter its position.

The group of points applies to individually operated points (see scheme p. 603) or to two sets of points linked together.

The working of a simple points alone will be described as that of a set in liaison can be deduced therefrom without difficulty. The direct current voltages used are 120 for operating the motor and 40 for the operating and control circuits. The set of points is in a right hand position for example (positive plug of the energised relay CAW). The control relay KAW is energised and its excitation circuit controls in a permanent manner out in the line the locking and the position of the blades of the points. The same current passes through the two bobins 1 and 2 of a differential relay KTA. This relay comes into action when there is an out of balance of the current of 0.015 A between its two windings and under these conditions causes the control relay KAW to drop by short circuiting its winding. This out of balance in the current may result either through operating the points or because of a defect in the cables (defective insulation or even a supply of current accidentally picked up by a wire through contact with a nearby wire).

To work the points a supply of current at G is brought by the methods described in the Second Part of the Report. Due to this, winding 2 of the differential relay receives more current than winding 1. The relay acts and causes the control relay (first time) to drop. This causes the energising of a relay with two windings called series relay SAW (second time) which cuts the feed to the control and differential relays and allows the position of the throw over relay operating the points CAW (third position) to change.

The working of the differential and control relays is therefore checked each time the throw over relay changes position. If this control relay remained stuck mechanically the points would be immobilised. The operation of the points along the line begins as soon as the throw over has changed over its position. The operating current passes through the second winding of the series relay and maintains it energised. During the changing of position of the throw over no current flows through the two windings of the series relay. This relay however remains energised thanks to an appropriate delay in the drop (0.2 sec). The name series relay is due to one of the windings of the relay being arranged in series in the operating circuit of the points immediately after the fuse. The object of such a relay is to allow some of the operating wires to the cables connecting the points to the signal box to be used as control wires after the points have been moved. The result is a substantial saving on the installation cost.

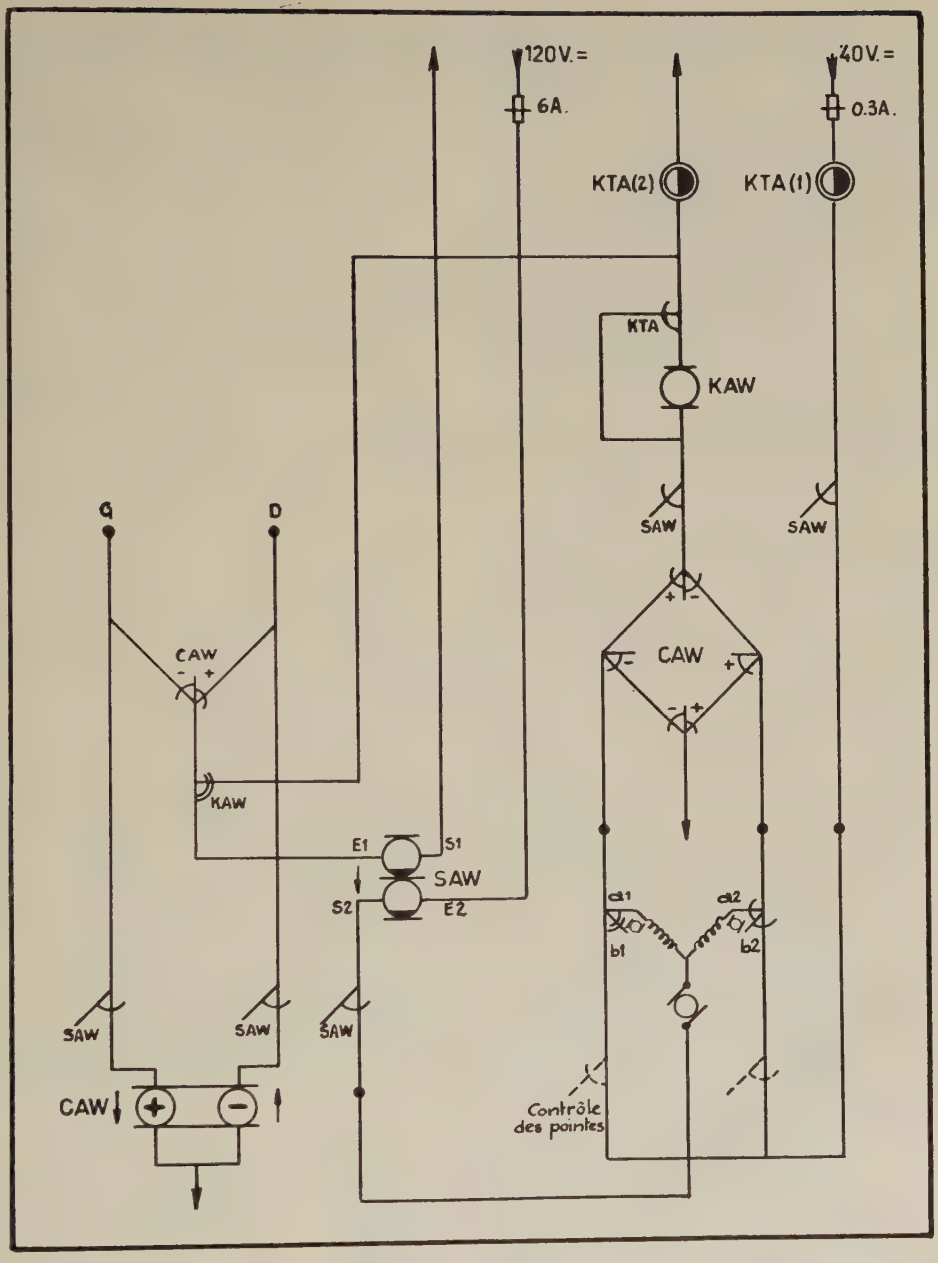
At the start of the travel of the motor, its contact a^2 goes to the closed position. A fast return of the points to its initial position is so made possible by cutting off the current at G and establishing it at D towards the throw over relay. In addition, the contact b^1 opens and so puts itself into the same position as b^2.

At the end of the stroke of the motor, the contact a^1 changes position as does b^2 so that the positions a^1, b^1, a^2, b^2 are the opposite to those in which they were when the stroke started.

The change of position of b^2 in many points operating mechanism is only possible if the shunting block signal is locked with the blades of the points in the correct position. In other appliances, the correct position of the points of the switch is shown by the closing of distinct contacts in the commutator.

The changing of the position of a^1 has the effect of de-energising the series relay SAW. On this occurring the control relay energises itself via the contact b^2 and the contacts for detecting the position of the points blade.

In the operating system described above, the position of the points in the open is therefore proved in the signal box by the corresponding stable position of the throw over relay and the energisation of the control relay.



Erratum. — In the above diagram the signs + and — in the symbol representing the CAW throw over relay should be reversed.

SECOND PART.

DESCRIPTION OF A SIGNAL BOX WITHOUT MECHANICAL INTERLOCKING OF THE S.N.C.B. TYPE

Introduction.

I. The principles followed.

A. Introductory note.

B. Description of interior equipment.

a) *The operating desk.*
- 1° *The keys for setting up a train movement.*
- 2° *The keys for selecting a movement.*
- 3° *The keys for cancelling a movement.*
- 4° *The keys for setting the signal to danger urgently.*

b) *The table of the block controller.*
c) *The optical control panel.*
d) *The relay room.*

C. Basic plans - Basic relays.

D. Case of train movements without intermediate treadle.

1. *Setting up the movement.*
2. *Selection of the movement.*
3. *Coupling circuits.*
   1. *Condition prior to the signal being taken off.*
   2. *Condition after the signal is off.*
   3. *Circuits properly speaking.*
4. *Operation when passing of the signal.*
5. *Restoration of the signals to danger.*
6. *Freeing circuits.*
   a) *Holding circuits.*
   b) *Reenergising circuits.*
7. *Accessory keys.*
   1. *Key cancelling the movement set up.*
   2. *Key for setting the signal to danger in emergency.*
   3. *Key cancelling the locking.*
   4. *Key cancelling the control of the track circuits.*
   5. *Key for cancelling the pedals.*
   6. *Various keys.*
8. *Approach interlocking.*
9. *Defects.*

E. Case of train movements with one or several intermediate treadles.

1. *Setting up the movement.*
2. *Selection of the movement coupling. Operation when passing the signals.*
3. *Freeing circuits.*
4. *Accessory keys.*
   1. *Key cancelling the movement set up.*
   2. *Key setting the signal to danger in emergency.*
   3. *Key cancelling the locking.*
   4. *Key cancelling the control of the track circuits. Key operating the locking. Various keys.*
   5. *Key for cancelling the pedals.*
5. *Defects.*
6. *Sectional points.*

SECOND PART. —

DESCRIPTION OF A SIGNAL BOX OF THE S.N.C.B. TYPE WITHOUT MECHANICAL INTERLOCKING.

INTRODUCTION.

The Belgian railway system has a hundred or so signal boxes with electric operation and individual levers distributed over the important stations of the country. In addition, since 1940 Brussels Midi Station has been operated by means of an electrified signal box using route levers. A similar box is at the Brussels Nord Station with a third under construction at Schaerbeek.

As far back as 1947, the S.N.C.B. was interested in signal boxes with free levers with no mechanical interlocking. It decided as an experiment to build a box of this type and selected Soignies for the purpose. This station is 35 km from Brussels, on the Brussels/Paris line. The old relay box put into service on the 26th January, 1952, was designed by the Westinghouse Company and the Ateliers de Constructions Electriques of Charleroi, in collaboration with the technical departments of the S.N.C.B. Two years operation of this station by this box have sufficiently clearly demonstrated the advantage inherent in the use of all relay signal boxes :

1) less space occupied due to the suppression of the interlocking table;

2) speed and simplicity of carrying out the movements;

3) ability to use without difficulty centralised operation of complete sets up of signals and points a long distance away;

4) ability to operate with reduced staff, large stations with intense traffic.

These advantages resulted in its being admitted in principle that the new signal box with electric operation would be without mechanical interlocking.

Previous to 1952, further all relay boxes were designed for Heyst, Alost and Vilvorde. As in the case of the Soignies box, the design and interior equipment were confided to private industry in collaboration with the competent department of S.N.C.B.

This method has its drawbacks. In particular, it results in the construction of signal boxes which are widely different one from the other as each manufacturer has his own designs and equipment. This is a serious drawback for the maintenance as for the operation of the installation, especially on a railway like the Belgian system which is not wide flung but is dense.

For these reasons, the technical department of the S.N.C.B. found it desirable to provide signal boxes to an original model, all the same and relatively cheap built with parts having well tried characteristic features and purchased on contact. The design and construction of these signal boxes would then depend entirely on the S.N.C.B. as was the rule for the classical boxes with individual levers.

The object of the present report is to describe precisely a type of signal box which is an original and economic solution of the problem. The schemes of

the inside equipment were thought out and perfected on the occasion of a new box serving parts of the installations of the Malines station, on the Brussels/Antwerp line. Put into service on the 4th October, 1953, the new box up to the present time has not given rise so far as the indoor installation is concerned to any failure. As a consequence of this success, the S.N.C.B. departments concerned decided to build the future signal boxes to the same principles. During 1955, four boxes of the S.N.C.B. type will be put into service at Waremme, La Hulpe, Saint-Ghislain, and the most important at Namur.

The design of the S.N.C.B. box is not only original but is relatively cheap.

A comparative investigation into the cost of previous installations using relays exclusively has shown that for equal quality and price of material (relays, operating table, optical control table) a saving of 20 % in the interior installation would be made by using the S.N.C.B. type and this *solely* through the appreciable reduction in the number of relays needed. If to this fact be added the advantages as regards repairs and operation through having one type of signal box and the greater flexibility when fitting up the box, it can be said, without exaggeration, that the average saving to be got for each new box is much higher than 20 %.

Let us consider in turn :

I. The principles on which the S.N.C.B. box were based.

II. The application thereof to the Namur box.

I. The principles on which the box was built.

A. Foreword.

The diagrams shown have been adapted to the usual operating conditions in the Belgian stations and the principles formulated by the technical service of the S.N.C.B., as regards outside installations. In this way :

(*a*) the points are operated in accordance with the fundamental diagrams described in Appendix II of the first part of the report;

(*b*) they are locked in accordance with the principles of the rigid transit by treadles (see first part of the present report);

(*c*) the signals, light signals by day and night, are operated by alternating current at 110 V. The operating relays are out on the line and these are alternating current safety relays;

(*d*) the track circuit relays are also safety relays with two windings supplied with alternating current at 110 V. They are permanently under voltage.

B. Description of the equipment in the signal box.

The inside equipment as a rule consists of :

(*a*) an operating stand;

(*b*) a stand for the block signalman;

(*c*) an optical control table;

(*d*) a relay room.

(a) *The operating stand.*

This stand has a series of free keys without interlocking or mechanical locking. These keys are grouped into :

1°) *Keys for setting up the movement.*

There is one key per journey completed during a train movement independently of the direction and of the nature of this movement. One particular key can therefore be used as for example for train departures and for the departures or the entries of shunting of rakes between one direction and a determined platform.

The keys for setting up a train movement are automatically restored to their normal position. They may be set in two or three positions according to the case :

1°) a neutral position at rest, stable;

2°) a position pushed or operated downwards to operate a movement;

3°) ultimately a position drawn or operated upwards to operate another movement. Usually this latter takes place between the same direction and the same platform line as the movement ordered in the other working position of the key but is carried out by another path.

The keys for setting up a movement are grouped in principle vertically by direction and horizontally by the platform lines. The number of columns of keys by direction as well as the number of banks of keys per platform line is fixed to suit local conditions so as to make the working of the deck the easiest and clearest possible.

2°) *The keys for selecting the movement.*

These are grouped by direction and with one operating position per direction and kind of movement to the direction. The keys are automatically restored to their out of use position and in principle can occupy three positions :

1°) neutral position at rest, stable;

2°) working position for an incoming movement whether normal entry or entry to a line occupied by a train or the entry of a shunt (the key being different for each of these kinds of movements);

3°) operating position for a departure movement (departure of a train or departure of a shunt).

3°) *The keys cancelling a movement (Keys NR).*

There is one per direction. These keys have two stable positions :

1°) neutral position at rest;

2°) working position for destroying a movement operated by direction so long as the signal authorising the movement has not yet been taken off.

4°) *The keys for setting signals to danger in emergency (keys SDG).*

These keys provided at the rate of one per direction have also two stable positions :

1°) neutral position at rest;

2°) a second position in which the key can play one of the two following roles :

1) to allow the signalman in case of danger to put to danger the signal authorising a movement from or towards the direction considered;

2) to prevent the signalman taking off the signal authorising a movement from or towards a direction even though all the requirements necessary for taking off the signal have been fulfilled. In this

case, obviously, the key should be placed in the operating position before the key selecting the movement is moved.

The operating table also has for each direction :

1) An indicator, which normally out, lights up, with a white light, when all the conditions needed to authorise a movement from or to the direction have been complied with. This indication can be repeated on the optical control board if desired;

2) Arrows lighted up with white light by the movement of the keys selecting the movement (one arrow per working position of the key). They check that the movement selection relays has correctly obeyed the movement of the selection key.

b) *The block signalman's desk.*

This generally speaking is combined with the operating desk, except when the zone served by the box is complicated and if the density of the traffic and the number of entries in the block or slot registers justify a signalman to operate the working and make the entries recording the trains.

The block signalman's desk comprises:

1) the keys for working the relays or the block apparatus;

2) the keys for transmitting the « slots »;

3) a telephone stand;

4) place at which to enter the notices in the block registers;

5) various illuminated indicators relating to the slots, block and telephone.

c) *The optical control board.*

The control board constitutes an indispensable element in working a signal box with free levers.

Placed so as to be clearly visible to the staff operating the box, it reproduces schematically but completely the track installation and the signalling operated from the box.

The optical control table normally is with the light out. Nevertheless even when no movement has been set up :

1) the control of the points is given permanently at each set of points by a white light which lights up when the control relay is excited and a red light in the contrary case;

2) an out of block transmitted is indicated by an illuminated white line;

3) an out of block received in the same way;

4) a slot received in the same way;

5) the warning of a train approaching an entry signal by a white or red illuminated line.

When moving a key setting up a train movement the route formed shows itself in white illuminated broken lines so far as the throw over relays for working the points have been set in the required position. At the same time, the optical control panel gives all the information needed concerning the signals, treadles, track circuits, block and slots in relation with the movement set up. These indications are shown for example as follows:—

Signals :

red lamp illuminated : signal on;
white lamp : signal not on.

Treadles :

illuminated white line : treadle free;

light out : treadles on which a train passes;

illuminated green line : treadle which has been pushed down and released by a train.

Track circuits :

illuminated white line : track circuit free;

illuminated red line : track circuit occupied.

Block :

white line : out of block transmitted (or received);

red line : out of block not transmitted (or not received).

Slots :

white line : slot received;

red line : slot not received.

These light indications appear at the table so long as the movement set up lasts. They disappear as the points are cleared by the train.

d) Relay room.

This is a building or a part of one only open to the maintenance staff. In the relay room, the relays needed for the operation of the signal box are grouped on suitable staging.

C. Basic plans. Basic relays.

The working programme for the station to be equipped enables the *signalling* plan, the table of train *movements* to be made, and the *operating desk* to be drawn in.

By hypothesis, the points are liberated by rigid transit with treadles or some equivalent arrangement. In addition to the direction treadles and the platform treadles, the position of certain intermediate treadles will be decided upon if the traffic density requires them. When a train movement is effected and clears an intermediate pedal the points lying between the beginning of the movement and this pedal are cleared whilst the others remain locked. The intermediate pedal therefore has the effect of hastening the freeing of part of the points involved in a movement so as to allow the setting up of the second movement which will pass over these points before the former movement is ended.

The presence of intermediate pedals leads us to consider a movement as composed of one or several parts called itineraries or routes and limited at the beginning and end by a treadle or any other similar device. Each route has its *operating* relay (CR) the role of which is to put into the required position the throw over relays of the points of the route. This relay also is used to make various selections in the circuits authorising the setting of the signals to clear. The plan of the *formulas* shows for each itinerary the position the points affected should occupy. Certain points, known as safety points are sometimes included in these formulae. They are passed over by the train which makes the movement corresponding to the formula in which these figure. Furthermore, their position is not, except in special cases, checked in the circuits authorising the signals being taken off. They are however worked with the object of keeping clear of the train movement a rake of

stock which, accidentally, might be circulating in the section after a shunt and without obeying the signals.

The whole of the points of the station is divided into zones of immobilisation or of transit. A zone is formed by a group of points over which only one single train movement can be made at a time. Each zone has a route immobilisation relay (IR) normally energised when each movement passing through the zone is not set up. If, on the contrary, a movement is set up this relay is de-energised and locks thereby the points in the zone. It is in fact checked when energised in the schemes for operating the points of the zone.

Besides the route operating and locking relays, three other types of relays are equally characteristic of the signal box considered. They are :

(1) movement *selector* relays (*S*).

These relays are energised by moving the movement selection keys. In principle, there is a relay for each active position of the selection key. As their name indicates, these relays mark the direction and nature of a movement made from or towards a direction;

(2) *monokinematic* relays (*M*) (sometimes known as operating locking relays CIR).

One is provided for each direction. These relays have the double duty of :

(*a*) locking the points of a set up route as soon as the points throw over relays are in the required position;

(*b*) make the operation of a movement monokinematic. A train movement having been set up and the authorising signal taken off, then restored to danger for any reason (out of order for example) the monokinematic relay prevents the operation of the movement cancelled being tried a second time;

(3) *coupling* relays (KR) (also called authorisation relays or route control relays).

Again there is one per direction. This relay is energised as soon as the necessary and sufficient conditions to allow the signal authorising a movement from or towards a direction to be taken off are fulfilled. The term « coupling » comes from the fact that with signals with disc, the magnetic coupling between the discs and the operating motor is effective as soon as the coupling relay is energised and ceases to function if the coupling relay is de-energised.

D. Case of train movements without intermediate treadles.

The basic diagrams relative to this case are given as appendix. It is well to refer to them continually to be able to understand satisfactorily the following text.

1. *Setting up the movement.*

To set up a movement for example from direction D towards platform line No. 1, the signalman moves a key for setting up a movement (*D-I*) and so allows under certain conditions the energisation of the corresponding route operating relay CR (D/I) :

a) The route operating relays (CR) have two windings. They are grouped by direction (C., fig. 1). The energising circuit is closed by moving an appro-

priate movement setting up key. At the same time checking :

(1) that the transit zone to the direction is free (that is relay IR of the locking zone to the direction energised);

(2) that the coupling relay KR to the direction is de-energised, that it has not therefore remained mechanically attracted through a preceding movement.

b) The energising of the route operating relay CR (D/I) results in the points throw-over relays concerned in the movement being placed in the required position (C., fig. 2) provided they are not immobilised by a movement in course of execution. This condition translates itself into the checking of the energisation of the corresponding locking relays IR in the diagrams for operating the throw-over relays CAW. The possible change of position of the throw-over operates the inversion of the position of the points on the line. The change over is made in a few seconds during which the relay controlling the points is de-energised.

c) The correct position of the throw-over relays is checked in the excitation circuit of a monokinematic relay M (C., fig. 3) formed in principle by a selection of points throw-over mechanisms CAW starting at the platforms to end at the directions. The selection is cut at the same time at the directions and at the platforms by contacts normally open of the route operating relays CR. Once attracted the monokinematic relay M maintains itself energised by a circuit passing through one of these contacts (C., fig. 1 and 3).

d) The attraction of the monokinematic relay M has two consequences :

1°) a circuit maintaining the excitation of the route operating relays is assured (C., fig. 1);

2°) by putting the points throw over mechanisms in the correct position, the circuits maintaining the excitation of the immobilisation relays IR for the transit zones through which the movement is made have been brought back to the direction. The excitation of this last relay therefore has the effect of making the relays drop and to immobilise the points concerned in the movement set up (C., fig. 7).

(*e*) As soon as the immobilising relays IR are de-energised the movement set up shows itself in broken illuminated lines on the optical control panel so warning the signalman that the movement he has ordered has been recorded (C., fig. 8).

(*f*) Furthermore, the treadles of the movement are put into circuit by the immobilising relays of the zones near which they are located (C., fig. 4).

To sum up the deliberate operation of a key for a movement set up :

(*a*) excites the route operating relay (C., fig. 1);

(*b*) causes the points throwing over gear to take the desired position;

(*c*) energises the monokinematic relay for the direction (C., fig. 3);

(*d*) immobilises the relays operating the points (C., fig. 7);

(*e*) lights up the path of the movement on the optical control board (C., fig. 8);

(*f*) prepares the treadle circuits (C., fig. 4).

The time which lapses between the instant when the key is moved and the moment when the path appears on the optical control board is short and less than one second. If the path does not appear after this short lapse of time two cases are possible : an incompatible movement is being made or something is out of order. This circumstance will be examined later on.

Let us remark (C., fig. 1) that the route operating relays check one another by a system giving the assurance that even if two keys setting up movements from the same direction were moved simultaneously one single route operating relay CR will maintain itself energised. These controls are on the supply side so as to guard against any danger from the accidental earthing of a contact. Only the contacts of the keys are on the earth side relatively to the excitation winding of the CR relay for the following reasons :

1°) a terminal of each contact of a key is in this way connected directly to earth which arrangement provides many facilities as regards the wiring;

2°) the keys used can be of a cheaper pattern, such as the telephone type for example, giving less safety than the relay contacts through in particular the little space between the contact terminals. With the system adopted :

(*a*) should a contact terminal be put under tension accidentally it would not affect safety because these contacts have an earthed terminal;

(*b*) accidentally earthing a contact could result in a movement being set up out of order provided no other incompatible movement was being made. The consequences as regards safety would not be serious except in the case when through another derangement the points of the movement being made should be freed prematurely whilst the train was running over them. Such a combination of circumstances obviously is most improbable.

2. *Selection of the movement.*

Once the movement is set up the signalman still should select its direction and kind. For this, he actuates the correct selecting key placed to the direction corresponding to the movement set up. The operation of the selecting key results in attracting a movement selecting relay (C., fig. 1).

The selecting relays are grouped by direction, one per each kind of movement. The excitation circuit of the selecting relay passes through a contact checking that the monokinematic relay M relating to the direction is attracted. Operating of a key selecting a movement therefore is only effective if the movement has been set up. Furthermore, the simultaneous operation of two selecting keys to the same direction only ends in the attraction of one selecting relay.

Once attracted the selecting relay remains energised, one of its contacts shunting the key contact and it is no longer possible by moving another selecting key to attract another selector to the same direction. An arrow at the control desk lights up and indicates to the signalman that the operation of the train movement and of the selection thereof has been recorded (C., fig. 9).

3. *Coupling circuits* (C., fig. 5).

The necessary conditions for taking off the signal are checked in the authorising circuits also known as the coupling circuits. Certain conditions are under permanent check before and after the signal is taken off; others only beforehand.

1) *Conditions before the signal is taken off.*

The conditions to be checked before taking off the signal can be divided into :

(*a*) conditions relating to the direction;

(*b*) conditions at platform;

(*c*) conditions between direction and platform.

a) *Conditions relating to the direction.*

These are, in general :

(1) *Those relating to the block :*

The way in which these conditions are characterised varies with the type and the block diagrams used as well as with the nature of the line : single or double track. If, for example, it is a question of a double track line equipped with automatic block :

(*a*) for a train to enter, there is nothing to control as to the direction;

(*b*) for a train leaving, the track circuit at the departure side of the station as far as the next signal met on the line ought to be free and this latter signal ought to have been restored to the on position by the previous train.

(2) *Those relative to the shunting track circuits on the departure sidings.*

These track circuits are controlled in the free position for a train departure or a departure for a shunt. They are limited on the one hand (station side) by a signal allowing the entry for shunting of a train, which has started to shunt towards the direction, on the other hand (line side), by a signal at the end of the shunt the passing of which has not been authorised by the shunting movements.

b) *Platform conditions.*

(1) For *an entry movement* (train or shunt) the control is that another entry movement on the same platform line and coming from a direction at the other end of the station has not been set up. This condition translates itself by controlling the excitation of an incompatible relay (IRA or IRB), if one box controls both sides of the station or of a slot receiving relay ROS if there is one box per side.

Similarly, the electric signal box ought to receive the authorisation or slot from an auxiliary box for an entry movement on to a fan of sidings, certain points of which are operated by the auxiliary box.

(2) When a train entry movement occurs, the platform track circuit ought to be clear.

(3) A *departure movement* generally does not involve any condition at the platform.

It is, in addition, necessary to check, for direction or at the platform, that the signal *at the end* of the movement set up has been set to danger during the previous movement. The control is either directly in the coupling circuit or indirectly in the block or slot circuits. If the signal is a light signal and is restored to danger by a safety relay no control is needed. Generally speaking, this last

solution is only used on the Belgian Railways in well defined cases : for example for a signal covering the entry into a station and at the end of an automatic block section.

c) *Conditions between directions and platforms.*

For a movement set up of whatever kind the check will cover :

(1) the attracted position of the KAW control relays of the points affected by the movement;

(2) the de-energised position of the IR locking relays of the points zones involved in the movement;

(3) the position of the treadle relays (RPV and V). A combination contact of rail-insulated rail can fill separately or simultaneously two roles :

(*a*) liberation of a route. The treadle is known as an end of itinerary treadle;

(*b*) restoration of a signal to the on position. The treadle is described as an automatic return to on treadle.

To satisfy these two functions as a rule the authorisation circuit is taken through a contact normally closed of the first treadle relay (RPV) in parallel with a contact normally closed of the second (V). This layout allows in particular the signal to go to stop automatically when the last pair of wheels of the train passes over the treadle.

If, on the other hand, the signal is restored to on by the safety relay at the first pair of wheels, the coupling circuit passes through one of the contacts, normally open, of this relay. The rail contact is then only necessary if the treadle is also used to mark the end of the itinerary. Under this proposition, a normally closed contact of the first treadle relay (1) is added to the authorisation circuit in series with the contact of the insulated rail relay.

2) *Conditions after the signal is taken off.*

The conditions to be controlled after taking off the signal are the same as before except as regards the track circuits which generally are not controlled any further as is the case with certain block conditions.

The fact of no longer controlling the track circuits after the signal is taken off has several advantages :

(*a*) In case of defective feed of the signals and track circuits through some defect, the coupling relays possibly energised with the signal off remain attracted as their circuit is on direct current. As

(1) This arrangement is not entirely free from objection. Let us take for example a concrete case : a signal covering the entry to a station is restored to danger by the first pair of wheels and departure movements towards this signal then become possible. The distance between the departure signal and the entry signal is short and less than the length of some trains. In this event, for a departure movement the treadle at the entry signal will possibly sometimes be depressed before the treadle at the depature signal has been entirely cleared. At this moment, the coupling relay de-energises itself and the signal goes to stop. The signal will go to stop therefore before the last pair of wheels passes over the treadle for placing the signal at stop automatically. If this drawback is to be avoided the arrangement shown as a variant of fig. 5 will be used. For a departure, the treadle will act as normal end of itinerary treadle whereas for an entry into section the coupling relay will drop as soon as the train runs on to the treadle at the entry signal.

soon as the feed with alternating current is re-established the signals restore themselves ultimately to clear. On the other hand with a permanent control of the track circuits in the coupling diagrams, the coupling relays fall if there is an interruption in the alternating current supply and after this feed has been restored the signals remain at stop as the coupling relays are not re-energised (being monocinematic);

(*b*) if an intermittent defect arises in a track circuit — through a defective fishplate for example — this defect will have no influence on the off position of the signal.

3) *Circuits properly speaking.*

The difficulty in drawing up the authorisation diagrams is due mainly to all the conditions described above having to be controlled for all directions by clear and simple circuits using the minimum of contacts and as a result being liable to the fewest derangements.

The authorisation circuits (C., fig. 5) of the all relay signal box, considered in this report include an authorisation (or coupling) relay KR per direction. In order that such a relay may be energised, it is necessary for :

(*a*) the monocinematic relay M for the same direction to be energised;

(*b*) all the conditions to be controlled *before* the signal is taken off have been met.

The excitation of the coupling relay KR causes the monocinematic relay M for the same direction to drop except in two particular cases we will consider later. The coupling relay KR then remains energised and controls the conditions before the signal is taken off. The commutation of the attraction circuit — holding circuit of the authorisation relay is made possible by delaying the drop of the monocinematic relay by sufficient time to permit the complete attraction of the coupling relay beforehand :

(*a*) the authorisation circuits commence by the control of the conditions applicable to the direction before and after the signal is taken off;

(*b*) then, selections by route operating relays permit the passage from the directions to the platforms and to control the conditions at the platforms;

(*c*) from the platforms the return to the directions is by means of a selection by point throw over mechanisms often called « grill », whilst controlling during this selection the conditions between platforms and directions common to all the movements.

The coupling circuits end at the KR direction relays. The energisation of one of these authorisation relays causes the de-energisation of the corresponding monokinematic relay (C., fig. 3) and the lighting up of a light signal at the operating desk (C., fig. 9) Moreover, the S selector and the CR route operating relays instead of remaining excited by a contact of an energised monokinematic relay this time remain energised by a contact of an energised coupling relay (C., fig. 1).

4) *Operation when passing the signals* (C., fig. 1).

The circuits for operating the signal lights when the trains pass are supplied

with alternating current. These start from the directions and control the energisation of the coupling relays and the de-energisation of the monokinematic relay relating to the direction considered. Then thanks to the selections by selector relays and route setting relays or points throw over mechanisms, the current is brought from the direction to the relays operating the signal on the line. On the line, the operating circuits are those in general use on the Belgian system. Fig. 6 gives an example of operating a simple signal out on the line.

5) *Restoration of signals to stop.*

When a train starts a movement set up and authorised, the authorisation signal can be restored to stop in two ways :

(a) *At the first pair of wheels.*

In this case, the KR coupling relay for the direction in question is de-energised as soon as the train runs on to the insulated rail in line with the authorisation signal (KR(E) - C., fig 5).

The circuit for operating the signal lights is cut for two reasons :

(1) the KR authorisation relay is de-energised;

(2) a contact of an insulated rail relay, controlling the excitation of this rail is inserted in the operating circuit (Signal E - C., fig. 6). This direct control is needed because it could happen that through a defect in construction the coupling relay remained mechanically attracted. Without this control, the signal would remain off and there would be no purpose in providing a safety relay for the insulated rail in order to be certain the signal had gone on. With the direct control, on the contrary, the authorisation signal goes on and remains at stop even when the train has cleared the insulated rail as the insulated rail relay can only be re-energised after the coupling relay (V [P.E.] - C., fig. 4) has been de-energised.

(b) *At the last pair of wheels.*

The authorisation relay (KR (D) - C., fig. 5) de-energises, when the two relays of the treadle of the authorisation signal are energised, that is to say when the train has cleared this treadle. Should the treadle at the signal get out of order the coupling relay remains energised until the moment the train clears the treadle at the end of the itinerary.

The de-energisation of the coupling relay causes the signal (C., fig. 6) be returned to stop, the de-energisation of the movement selector relay S and that of the route setting up relay CR (C., fig. 1).

6) *Releasing circuits* (C., fig. 7).

The zone locking relays IR remain without current so long as the train has not cleared — or liberated — the itinerary.

The liberation circuits of the signal box described consists of two parts :

the first formed by the circuits holding the locking relays IR;

the second formed by their re-energisation circuits.

(a) *Holding circuits.*

The holding circuits are carried out beginning at a selection of points throw over mechanisms CAW starting from

the directions to end at the platforms. At each direction, the corresponding locking relay IR maintains itself by its own contact and through a contact normally closed of the monokinematic relay. The other relays of the zone receive their holding current either from a supply at the direction or from supplies directly taken off the contacts of the point throw over gears according to the position of the latter. These relays are retarded as regards coming off so as to remain attracted long enough for the contacts on the throw-overs to be changed during the setting up of the movement. Such a set up has the effect when putting the points throw over mechanisms in the required position, of restoring, to the direction, the holding circuit of all the IR locking relays concerned in the movement set up. Then at the moment when the monokinematic relay M relating to the direction is energised, the IR locking relays are de-energised.

(b) *Re-energisation circuits.*

The re-energisation of the locking relays takes place through the intermediary of a selection by points throw over mechanisms beginning at the platforms and ending at the directions where they reconnect to the holding circuits. The re-energisation circuits control the following conditions :

At platform :

treadle released (first relay RPV and second relay V attracted);

signal at stop (control relay KFS of the signal at stop energised);

slot receiving relay ROS de-energised.

At the direction :

treadle cleared;

signal on;

final conditions of block or slot;

coupling and monokinematic relays de-energised.

At the moment the locking relays IR of the movement liberated are re-energised the circuits of the first (RPV) and second treadle relay (V) are cut (C., fig. 4). This is why these relays are retarded in falling long enough to allow the immobilisation relays to be re-energised.

This re-energisation has the effect in particular of blotting out, on the optical control panel, the illuminated indications relating to the movement that has been cleared (C., fig. 8).

7) *Accessory keys.*

Now let us consider the function of the various accessory keys of the signal box :

1) *Key for cancelling the movement set up* (NR).

There is one for each direction. To be effective the operation of this key requires the monokinematic relay (C., fig. 7) to be attracted. The authorisation signal for the movement has therefore not been taken off yet.

By moving the key under optima conditions the locking relays IR de-energised when the monokinematic relay (C., fig. 7) was re-energised, re-energise themselves whereas the route setting relay and possibly the selection relay drop through the interruption of their maintaining circuit (C., fig. 1). The

monokinematic relay M falls also without current and is de-energised (C., fig. 1 and 3) with nevertheless by its constructions a sufficient delay to allow the making of the maintaining circuit of the locking relays IR.

2) *Key for setting the signal to danger in emergency* (SDG).

There is also one of these per direction. This key has a double role to play :

1) a contact placed, by direction, in the operating circuits for controlling the signal lights (C., fig. 6) on passing enables, for a train movement authorised and set up, the signal to be put back at stop while maintaining the points immobilised. Moving the key has at the same time the effect of de-energising the route operating relays CR and the movement selecting relays S (C., fig. 1). Thereupon, the authorisation relay KR also falls (C., fig. 5) and it becomes impossible once the key has been operated to take the signal off again by replacing the key in its normal position;

2) if before the coupling relay KR is attracted the emergency stop key is used and it is left in its working position the signal can be kept on whilst the coupling relay is being re-energised. Actually, thanks to the contact of the SDG key in the monokinematic relay M (C., fig. 3) circuit, this latter relay remains energised. To take off the signal all that is needed is to restore the SDG key to its normal position. If the SDG key is then moved again the consequences foretold under 1 of this paragraph will occur.

3) *Key for cancelling an immobilisation* (NI).

There is one with two stable positions per direction, one the neutral position at rest and one the working position. This key, according to the regulations in force on the Belgian system can only be used by a qualified train movement employee (station master or his deputy), the signalman not being allowed to do so. It is fitted with a lead seal or recording device and is not necessarily part of the operating desk. It will be placed for example in a cupboard out of reach of the signalman. Its use is bound up with the regulations applicable to its function.

The cancellation key (NI) is used in the case in which a train having completed the movement, the points remain immobilised through some defect (at the treadle or at a signal or slot...) in the liberation circuit. A contact of the key moved (C., fig. 7) sends directly to the direction, current to the points locking relays (IR) and thereby liberates them. At the same time, another contact of the key cuts the feed circuit of the selectors S and route operating CR relays for the movement (C., fig. 1).

4) *Key cancelling the control of the track circuits* (NV).

There is one per track circuit. This key with self-return has two positions. Its use is subject to the same restrictions as in the case of the NI cancellation keys. A contact of the key in its working position bridges the control of the corresponding track circuit in the authorising circuit (C., fig. 5) and then allows the signal to be taken off in spite of a defect in the track circuit.

5) *Keys for operating the locking* (CIR).

These keys have two positions with automatic return to a stable position. One is provided per direction.

The keys operating the locking are brought into action under two sets of circumstances :

(*a*) in certain cases in which a train movement after being set up (relay M energised) and selected (relay S attracted) reveals a defect in coupling (the relay KR will not energise).

The authorising signal cannot then go to pass and the train has to make the movement by means of a passing order. Operating the CIR key has the result in this case of making the monokinematic relay M falls and to lock the points in the same way as if the coupling relay was energised. The fall of the monocinematic relay M causes the de-energisation of the movement selector relays S and the route operating relays CR (C., fig. 1 & 7);

(*b*) when the train movements are set up in an unusual way.

Train movements set up in this way are made for example by putting the points in the required position by means of the keys for the individual operation of the points (see below). They are locked by means of the key operating the locking for the corresponding direction. This manœuvre results in the de-energisation of the IR locking relays of the points over which the journey set up will pass. The points immobilised will be released by the train (C., fig. 1 and 7).

6) *Various keys.*

(*a*) Each point has a key for individual operation AW with automatic return and for three positions so enabling the signalman to reverse the position of the points without having to set up a movement. The displacement of the key is only effective if the locking relay of the points is energised (C., fig. 2).

(*b*) Various other keys are provided at the block controller's table for the slots, blocks, telephone communications, etc.

(*c*) Keys for consulting the optical control panel placed at the operating desk or the table of the block controller which, when used, attract auxiliary relays DPK. The operating circuits of the optical control panel (C., fig. 8) show clearly that thanks to these keys it is possible at any moment to consult the panel to ascertain the position of points not used in a train movement or to learn if a track circuited line is free or not.

8) *Approach locking.*

The definite locking of the points of a movement takes place at the moment the coupling relay KR is attracted in so far as the placing of the authorisation signal to clear has not been reserved by a previous operation of the SDG key. In certain cases of train entry movements, it is useful to retard the definite locking of the points until the moment the trains run on to an approach zone before the signal covering the entry whilst having already permitted this signal being set to clear. With this purpose in view it is possible to proceed as follows :

1°) a safety relay ZAN (C., fig. 10) corresponds to the approach zone. This normally energised relay de-energises as soon as one of the approach zone track circuits is occupied. It re-energises when these track circuits are clear and when in addition the entry path is free (IR locking relay for the direction attracted);

2°) so long as the zone approach relay is excited the locking of the points of the movement set up and selected with the signal off can always be unlocked by operating the cancellation key NR (C., fig. 7*bis*).

9) *Defects.*

We do not intend in this report to examine all the cases of defective working which can arise nor the resulting steps to be taken. We shall be content to make some remarks and to call attention to some particular points.

1) When through any derangement, there is a defect in the coupling for a movement set up, the delivery of a passing order at the authorisation signal has to be completed by the precautions laid down in the regulations of the signal box.

2) When there is a defect in coupling a connection, the regulations require before a permit to pass over the section is issued either that the lines feeding the motors of the points to be run over are cut out or that the direction cancellation key NR be locked, or that current be cut off of the direction «monokinematic» relay M by moving the corresponding key CIR. These measures have as their objective the prevention of the undesired operation of points under the train making the movement.

3) The colour light signals are controlled *at danger* by a control relay KFS. If relay KFS de-energises itself :

(*a*) with the train movement set out and authorised by the corresponding signal, it means that the signal is no longer at danger. It is probably at clear but it can also be out for example because the lamp giving the pass light is defective. At the visual control diagram, the white light attached to the signal lights up (C., fig. 8);

(*b*) when no route has been set then the signal is out or wrongly at clear. The control circuits of the usual control diagram (C., fig. 8) are laid out in such a way that in this event the red light attached to the signal flickers. It is supplied with current from a blinking service passing through a locking relay near the signal under attention and the control relay KFS of this disexcited signal.

4) If, owing to any defective construction, a coupling relay KR maintains itself mechanically coupled two cases have to be considered :

(*a*) the signal returns to danger as the moment the first pair of wheels of the train runs on to the insulated rail at the foot of the signal (C., fig. 6). The insulated relay once disexcited by the train remains down so long as the defect in the coupling relay KR persists (C., fig. 4);

(*b*) the signal goes to danger at the passage of the last pair of wheels. In this case, it remains at off although the train has cleared the path. To put it to danger the signalman operates the

emergency « on » lever (SDG) for the direction (C., fig. 6).

In both cases, the points remain locked (C., fig. 7). To release them, the signalman dealing with the train movement sets the key NI to the required direction. Starting from this moment, obviously it should not be possible to set up any movement from or towards the out of order direction. This is the reason why in the excitation circuit of the route operating relays the de-energised coupling relay KR (C., fig. 1) is controlled.

5) In the case in which a route operating relay CR remains energised although without current, the route set up, once run over, is cleared but sets itself again immediately (C., fig. 3). The signalman will move the route cancellation key NR and thereby maintain the energised relays locking the points IR (C., fig. 7). It must be noted however that all the points concerned in the route set up by the out of order relay are locked in the position this relay sets, even when the relay locking the point is energised.

When it is desired to reverse the points, current is applied to the two windings of the switch throw over mechanism CAW. This will then remain in its original position. To change the position of the points, it has to be done manually by a lever.

6) When a movement selection relay remains wrongly energised, the signalman will have to move the key SDG to the corresponding direction when a movement is set up relating to that direction.

7) Two movements selecting relays for the same direction cannot be energised simultaneously even in the case of a relay mechanically operated or the selection keys (C., fig. 1) actuated simultaneously.

8. The rules forbid a signalman to try to set up at the same time two train movements starting from the same direction. In no event, however, could such an operation be dangerous as regards safety. To illustrate this, let us consider a concrete example : movements between direction D and the platform lines I and II :

(*a*) The keys for itineraries D-I and D-II are operated simultaneously. In this case, relay D-II is energised and finally maintains itself closed (C., fig. 1);

(*b*) The train movement D-I having been set up, the movement D-II is set in motion. The operation will not have in general any effect because at this moment the locking relay IR (D) is de-energised. It is possible, however, it might not be for two reasons :

(1) the movement D-I cannot be set up because an incompatible movement coming from another direction has been authorised. In this case, should the signalman who operates the key D-I move at the same time the key D-II, the relay CR (D-II) is attracted and de-energises instantaneously the relay CR (D-I) (C., fig. 1);

(2) the movement D-I is set up but the signalman is quick enough to operate the key D-II before the relay IR (D) is de-energised even though the monokinematic relay M (D) may have been attracted already. In this case, the relay CR wish to be energised but is stopped

when the relay IR (D) falls. In any case, there will be no circuit to maintain, as in the latter case, the relay CR (D-I) is controlled as de-energised;

(*c*) the relay CR (D-I) is attracted mechanically. The relay M (D) for the direction is then also attracted permanently (C., fig. 3). Let us suppose the signalman has operated the key NR (D) to keep energised the locking relay IR and, in particular IR (D) (C., fig. 7). The signalman then sets up the movement D-II : the relay CR (D-II) becomes energised but does not remain so should the signalman restore the key NR (D) to its normal position with a view to locking the points.

9. It is forbidden also to set up at the same time two incompatible movements coming from different directions. Reasoning as in the preceding paragraph, it will be seen that this forbidden operation even if it were made could have no dangerous effect on safety. As most, in certain cases, might the monokinematic relay be energised wrongly : this would not be serious if at the same time the energising of the coupling relay could not take place as in the case we are considering.

E. Case of train movements towards one or several intermediate treadles.

This case is very similar to the previous one but with several complementary arrangements.

1. *Set up of the train movement.*

To each route a route operating relay CR is attached.

The CR relays to the direction have an energising circuit and a holding circuit exactly the same as those of the previous case.

The CR relays at the intermediate treadle (D., fig. 1) are connected together in groups having as origin on the « *direction side* » the same treadle.

Their excitation circuit is completed if one of the keys setting up the corresponding train movement is operated and if, in addition, the locking relay at the origin on the direction side of the route is energised.

The holding circuit passes through a contact normally open of the operating route relays CR of the routes having as their end « *platform side* » the intermediate treadle. It therefore controls whether one of these relays is energised. It is usual practice for these contacts to be equally spaced in the excitation circuit though this is not essential.

The attraction of the route operating relays causes the points throwing over relays to take up the required position and the energising of a monokinematic relay for the direction, followed by the fall off of the locking relay of the IR zones exactly as in the case of movements without intermediate treadles.

2. *Selection of the train movement. Coupling.*

The circuits selecting the movement, the coupling and the operation of the signal lights on passing them do not differ in principle from the preceding cases.

3. *Liberation* (D., fig. 3).

The liberation circuits, on the other hand, are somewhat different. The circuits holding the locking relays IR re-

main the same whereas the energising circuits which control the condition of liberation are divided into several parts coupled in the holding circuits at points situated according to the directions or to the intermediate treadles. The parts coupled to the directions form a selection of points throwing over mechanisms starting from the first intermediate treadle and terminating at the directions. Those attached to the first intermediate treadle form a new selection starting from the two second intermediate treadles to end at the first and so on into the parts forming a selection of the platforms to end at the last intermediate treadles.

When a train completes a movement composed of a number of routes, it is essential that at each intermediate treadle all points the train has already passed shall be freed and this irrespective of the direction in which the train movement takes place. It is precisely for this object that the re-excitation circuits have been divided into elements each corresponding, for a specific train movement to a route. The intermediate treadles, at the intermediate points separate the locking relays of the points run over from those not yet encountered in order to make it possible to re-energise the former.

With this object in view, the second V relay of an intermediate treadle maintains itself energised only by means of a contact normally closed of the locking relays towards the direction, whereas the first RPV relay is maintained energised both by a contact normally closed of the IR relay towards the platforms and by a contact normally open of the second V relay (D., fig. 2).

First case. — The train makes the movement in the direction-platform sense.

After the train has passed over the first intermediate treadle, the IR locking relays between the direction and this treadle re-energise themselves (D., fig. 3*a*). At once, the second V relay of this treadle falls without current whilst the first RPV relay remains attracted (D., fig. 2). The re-energising current of the other IR relays is stopped at the first intermediate treadle by a contact of the first RPV relay in series with a contact of the second V relay. If then the RPV relay should fall accidentally without current it would still be necessary for the V relay to remain mechanically attracted if the re-energising current were not to be cut off. Any such combination of circumstances cannot be taken into consideration.

After the train clears the second intermediate treadle the IR relays between the two treadles re-energise themselves (D., fig. 3*b*). The RPV relay of the first intermediate treadle de-energises itself (D., fig. 2) and the current for maintaining the IR relays coming from the direction flows to the second intermediate treadle.

Second case. — The train makes the movement in the platform-direction sense.

The route between the platform line and the first intermediate treadle beyond the platform having been covered the points run over release themselves (D., fig. 3*b*). At the intermediate treadle the two treadle relays remain attracted (D., fig. 2). Moreover, a holding circuit

of the re-energised IR locking relays establishes itself at the intermediate treadle via a contact of the IR relay, platform side, and a contact of the first relay RPV treadle. If this relay accidentally de-energises itself the holding circuit is cut and the locking relay previously re-energised drops again. The resulting disorder does not affect safety of working.

After passing the following intermediate treadle, a new route is freed, the two relays of the first intermediate treadle fall and the circuit for maintaining the re-energised IR relays restores itself at the last treadle passed.

The treadle and locking relays are sufficiently delayed in falling to allow the commutations with interruption of current of the holding circuits described above.

4. *Accessory keys.*

1) *Key for cancelling the route* (NR).

This key has the same function as in the case in which the train movement is composed of a single route (D., fig. 3). Let us note however, one particular feature of the present case, the circuit for re-energising the locking relays obtained by operation of the path cancellation key to the direction, passes at the intermediate pedal through a contact normally open of the second treadle relay. Usually, this relay has been attracted by the dropping of the corresponding locking relay. Should through any derangement the second relay remains de-energised, the operation of the path cancellation key is only effective as far as the intermediate treadle. In this exceptional case, the locking relays beyond the intermediate treadle will be re-energised by the locking cancellation keys, NI, used when the movement authorising signal has been taken off (keys sealed, or with a device recording the number of times operated).

2) *Emergency closing key* (SDG).

This plays the same role and works in the same way as in the case in which the train movement consists of a single route.

3) *Locking cancellation key* (NI).

At each end of the train movement (direction or platform), there is a corresponding key. It resets itself automatically and has two positions :

(*a*) neutral position — when not in use;

(*b*) operating position.

This key is operated in the event of the release conditions of the direction or at platform of a train movement not functioning due to some derangement. This key can only be used by the operating department employee authorised to do so and only after all the precautions laid down by the regulations have been fulfilled.

4) *Cancellation keys of the control of the NV track circuits of the operation circuits of the CIR locking and various keys.*

These keys play the same role as in the case of train movements without intermediate treadles.

5) *Treadle cancellation key (NP).*

When an intermediate treadle is defective, a cancellation key with two stable

positions enables when in the working position this treadle to be cut out in all the train movements affecting it. The key when in the working position ensures that the contacts of the two relays of the intermediate treadle are « shunted » in the release circuits and that current is cut off the circuit of the first relay of this treadle.

After such a key has been operated by the qualified operating employee, the trains will run normally with this restriction however that their release will be less spread out through the suppression of the intermediate treadle.

The keys cancelling the treadles are either sealed or fitted with recorders showing the number of times they are used in order to check their working.

5. *Derangements.*

What has been said when considering train movements without intermediate treadles is equally applicable to the present case. Let us formulate however the two following complementary observations :

(1) When apart from any path, a rail contact functions irregularly, the first treadle relay is energised and remains attracted so long as the rail contact is short circuited.

At the time a path is set up passing by the out of order treadle, the monokinematic relay relating to the direction by becoming attracted causes the locking relays between the direction and the out of order treadle to fall but not those beyond (D., fig. 3).

Actually, the moment the first relay of the out of order treadle becomes energised in error, a commutation of the holding circuit of the locking relay occurs at the out of order treadle. The new holding circuit for the locking relays towards the platforms passes through a contact of the first energised treadle relay and a contact of the locking relay on the platform side, to the out of order treadle. This circuit is not influenced by the monokinematic direction relay. Such an arrangement is free from any defect. In fact :

1°) in any event, the permissive signal cannot be taken off;

2°) before issuing a permit to pass, the removal of the fuse from the operating circuits of the points to be run over can be insisted upon;

3°) even if not removed and so long as the monokinematic relay remains energised the points are locked directly by the energised relays operating the path.

(2) If two path keys are operated simultaneously it is possible in certain cases to obtain a path not required.

Example : the movements M-PI-I and N-PI-II are set up simultaneously. Before any path was set up, the points are set on the line in the sense M-PI-II. It is this latter train movement that will be set up without any loss of safety.

6. *Points for dividing the lines into sections.*

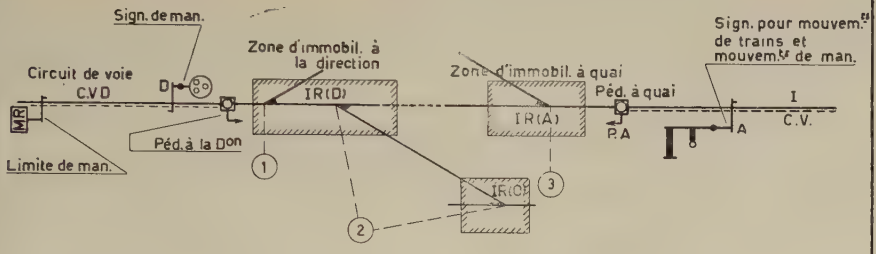
With certain arrangements, there is an advantage to divide up routes without treadles. In this way, the result sometimes is to reduce both the number of points to be operated by each route

operating relay CR and the number of these relays. If, for example, three routes have a common point and give access from this point to six platform lines, the setting up of a sectionalising point at the common point will enable train movement set-ups to be realised using nine route operating relays (3 plus 6) whereas without this sectionalising point the double (3×6) would have been necessary.

The CR relays limited by sectionalising points affect the plans on the same way as the ordinary CR relays. As in the track itself, the sectionalising points have no corresponding device, they play no part in liberating the locking zones.

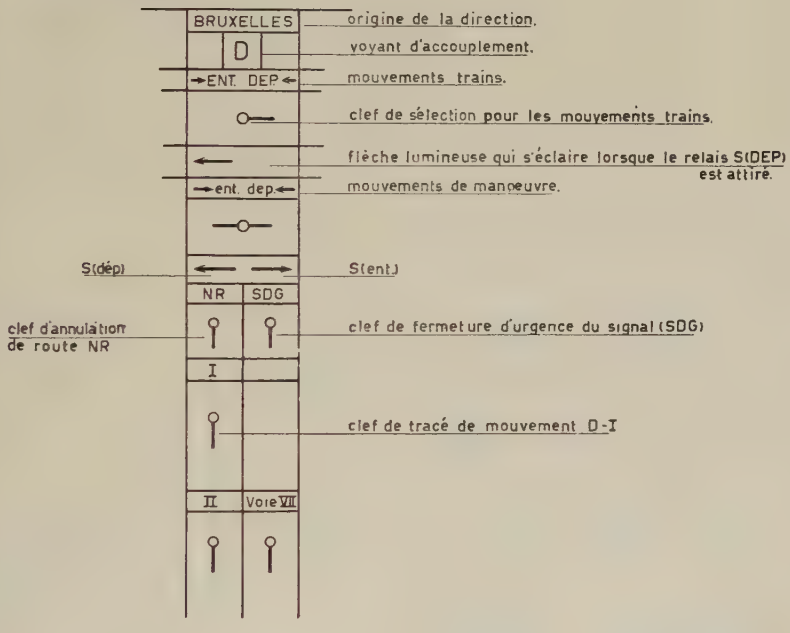
Deuxième partie – Annexe.

MOUVEMENTS SANS PEDALE INTERMEDIAIRE.



A. Mouvement : D-I = $\frac{1}{2.3}$ aig. 1 à droite
aig 2 et 3 à gauche.

B. Pupitre de commande.

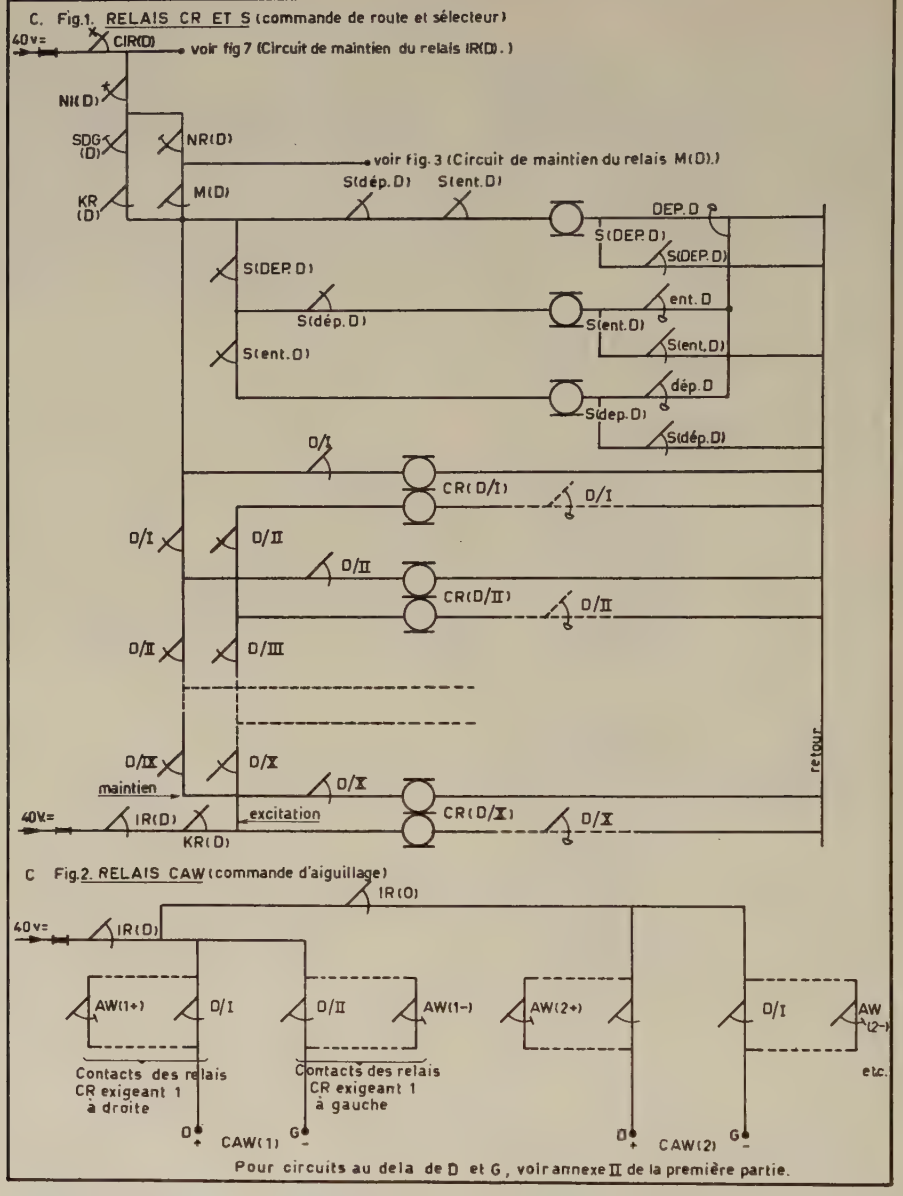


Translation of the French text:

SECOND PART — APPENDIX.

Train movements without intermediate treadle.

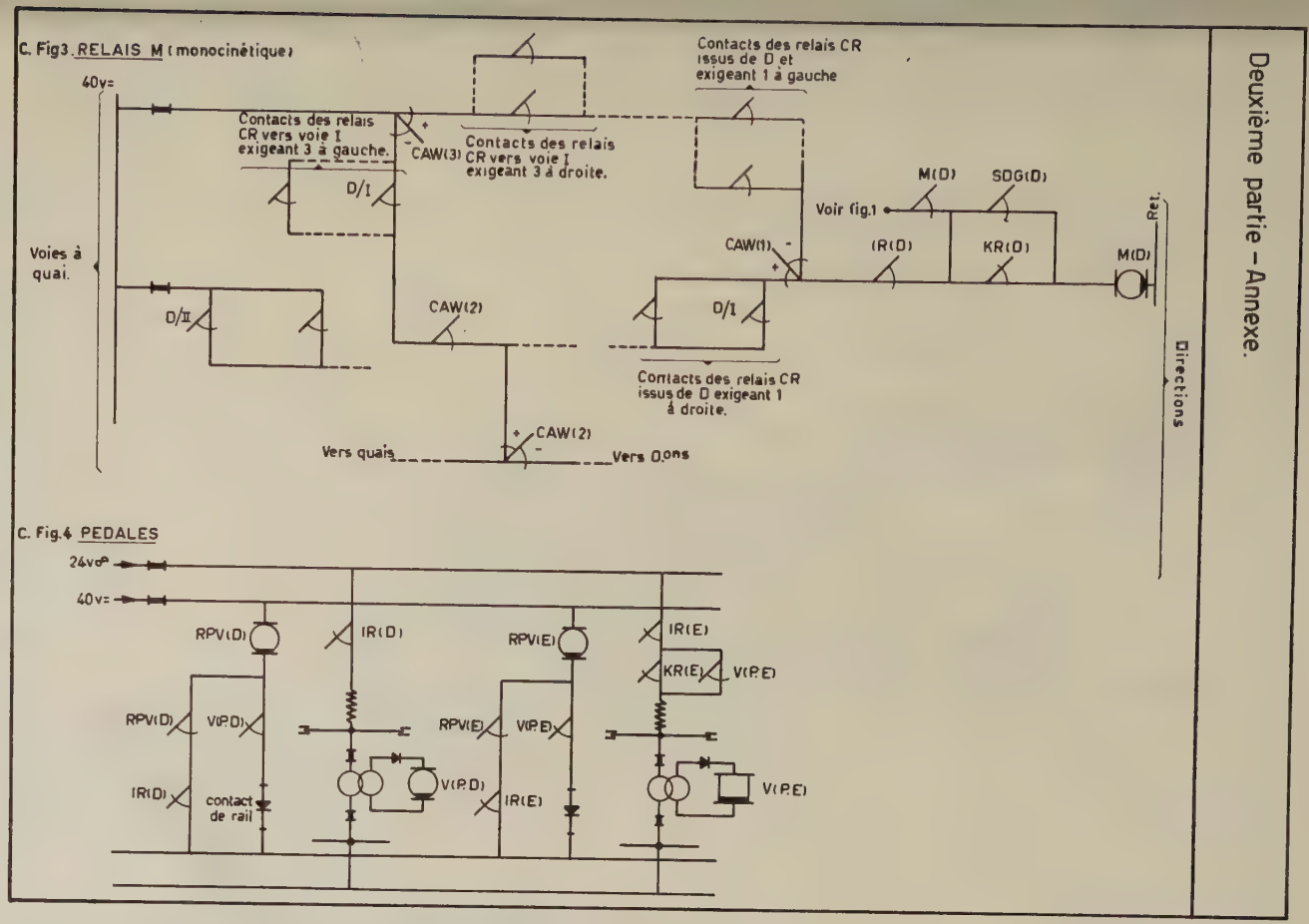
Circuit de voie = track circuit C.V.D. — Sign. de man. = shunt signal. — Ped. à la Don = treadle for the direction. — Zone d'immobil. à quai = platform locking area IR (A). — Zone d'immobil. à la direction = direction locking area IR (D). — Ped. à quai P.A. = platform treadle P.A. — Sign. pour mouvements de trains et mouvements de man. A = signal for train movements and shunts. — Limite de man. = shunting limit. — MR Limite de man. = MR Limit of shunt. — A. Movement D-1 $\frac{1}{2.3}$ aig. 1 à droite, aig. 2 et 3 à gauche = movement D-1 $\frac{1}{2.3}$ points 1 to right, points 2 and 3 to left. — B. Pupitre de commande = operating desk. — Bruxelles = Brussels. — Origine de la direction = starting point of the direction. — D. Voyant d'accouplement = coupling sight. — ENT. DEP. : mouvements trains = entry-departure : train movements. — O - clef de sélection pour les mouvements de trains = selection key for the train movements. — Flèche lumineuse qui s'éclaire lorsque le relais S (DEP) est attiré =luminous arrow lighted when the relay S (DEP) is attracted. — Ent. dép. mouvements de manœuvre = entry-departure shunt movements. — S (dép.) S (ent.) = S (departure) S (entry). — Clef d'annulation de route NR = key cancelling route NR. — Clef de fermeture d'urgence du signal (SDG) = key for emergency putting signal (SDG) to danger. — Clef de tracé de mouvement D-I = key for setting up train movement D-I.



Translation of the French text:

SECOND PART — APPENDIX.

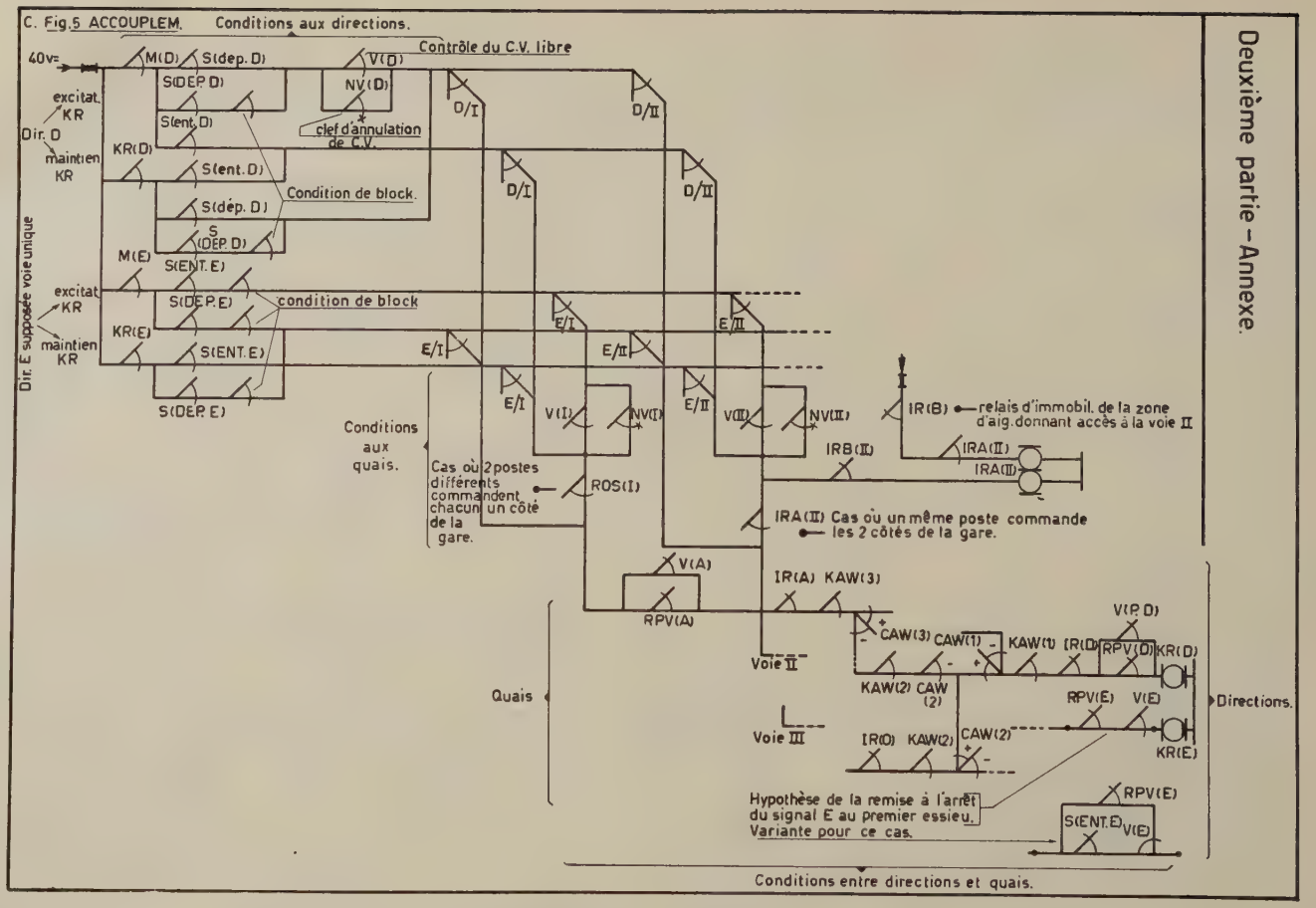
C. Fig. 1. Relais CR et S (commande de route et sélecteur = C. Fig. 1. Relays CR and S (operating the route and selector). — CIR (D) voir fig. 7 (Circuit de maintien du relais IR [D]) = CIR (D) see fig. 7 (Holding circuit of relay IR [D]. — NR (D) voir fig. 3 (Circuit de maintien du relais M [D]) = NR (D) see fig. 3 (Holding circuit of the relay M [D]). — Maintien = holding. — Retour = return. — Excitation = energising. — C. Fig. 2 Relais CAW (commande d'aiguillage) = C. fig. 2 Relay CAW (operating the points). — Contacts des relais CR exigeant 1 à droite = relays contacts CR requiring 1 to the right. — Contacts des relais CR exigeant 1 à gauche = relays contacts CR requiring 1 to the left. = Pour circuits au-delà de D et G, voir annexe II de la première partie. — For circuits beyond D and G, see appendix II of Part one.



Translation of the French text:

DEUXIEME PARTIE — ANNEXE = PART TWO — APPENDIX.

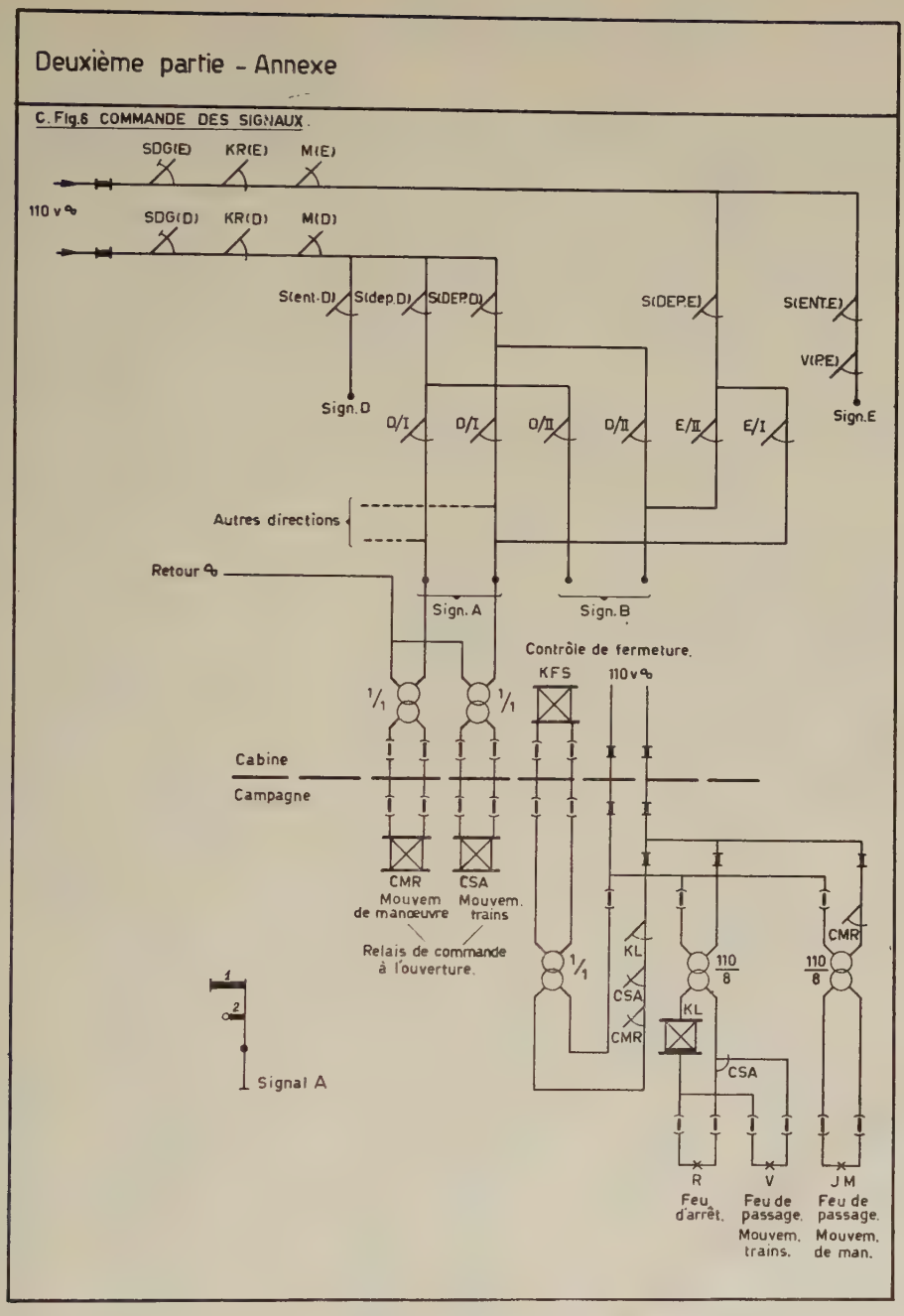
C. Fig. 3. Relais M (monocinétique) = C. Fig. 3. Relay M (monokinematic). — Contacts des relais CR issus de D et exigeant 1 à gauche = contacts of the CR relays issuing from D and requiring 1 to the left. — Contacts des relais CR vers voie 1 exigeant 3 à gauche = contacts of the CR relays to track 1 requiring 3 to the left. — Contacts des relais CAW (3) CR vers voie 1 exigeant 3 à droite = contacts of the CAW (3) CR relays to track 1 requiring 3 to the right. — Contacts des relais CR issus de D exigeant 1 à droite = contacts of the CR relays issuing from D requiring 1 to the right. — Voies à quai = platform lines. — Vers quais = to platforms. — Vers dons = to directions. — C. Fig. 4. Pédales = C. Fig. 4. Treadles.



Translation of the French text:

DEUXIEME PARTIE — ANNEXE = PART TWO — APPENDIX.

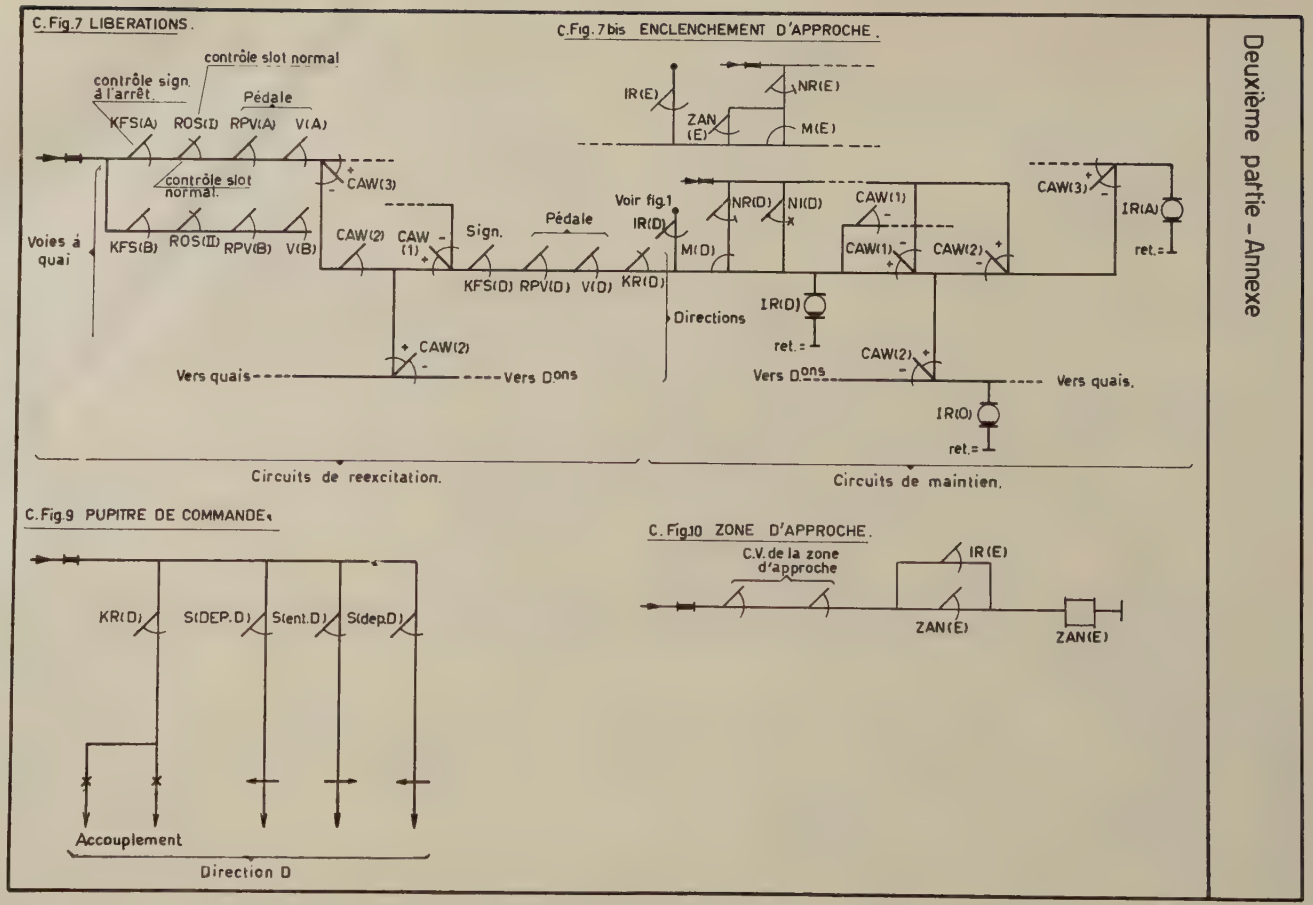
C. Fig. 5. Accouplem. Conditions aux directions = C. Fig. 5. Couplings. Conditions relating to the directions. — Contrôle du CV libre = check of CV when free. — Excitat. KR = energising KR. — Maintien KR = holding KR. — Clef d'annulation de CV = cancellation key for CV. — Condition de block = block condition. — Conditions aux quais = conditions at the platforms. — Cas où 2 postes différents commandent chacun un côté de la gare = case in which 2 different signal boxes operate each one side of the station. — IR (B) - relais d'immobil. de la zone d'aig. donnant accès à la voie II = IR (B) - relays locking the area of points giving access to track II. — IRA (II) Cas où un même poste commande les 2 côtés de la gare = IRA (II) Case in which one given signalbox operates both sides of the station. — Hypothèse de la remise à l'arrêt du signal E au premier essieu. Variante pour ce cas = hypothesis of the signal E being placed at danger at the first axle. Variant for this case. — Dir. E supposée voie unique = direction E supposed to be single track. — Conditions entre directions



Translation of the French text:

DEUXIEME PARTIE — ANNEXE = PART TWO — APPENDIX.

C. Fig. 6. Commande des signaux = C. Fig. 6. Operating the signals. — Autres directions = Other directions. — Retour = return. — Contrôle de fermeture = check of signals going to danger. — Cabine = signal-box. — Campagne = open line. — Mouvem. de man. = shunt. movements. — Mouvem. trains = train movements. — Relais de commande à l'ouverture = relais taking the signal off. — Feu d'arrêt = stop light. — Feu de passage = passing light.

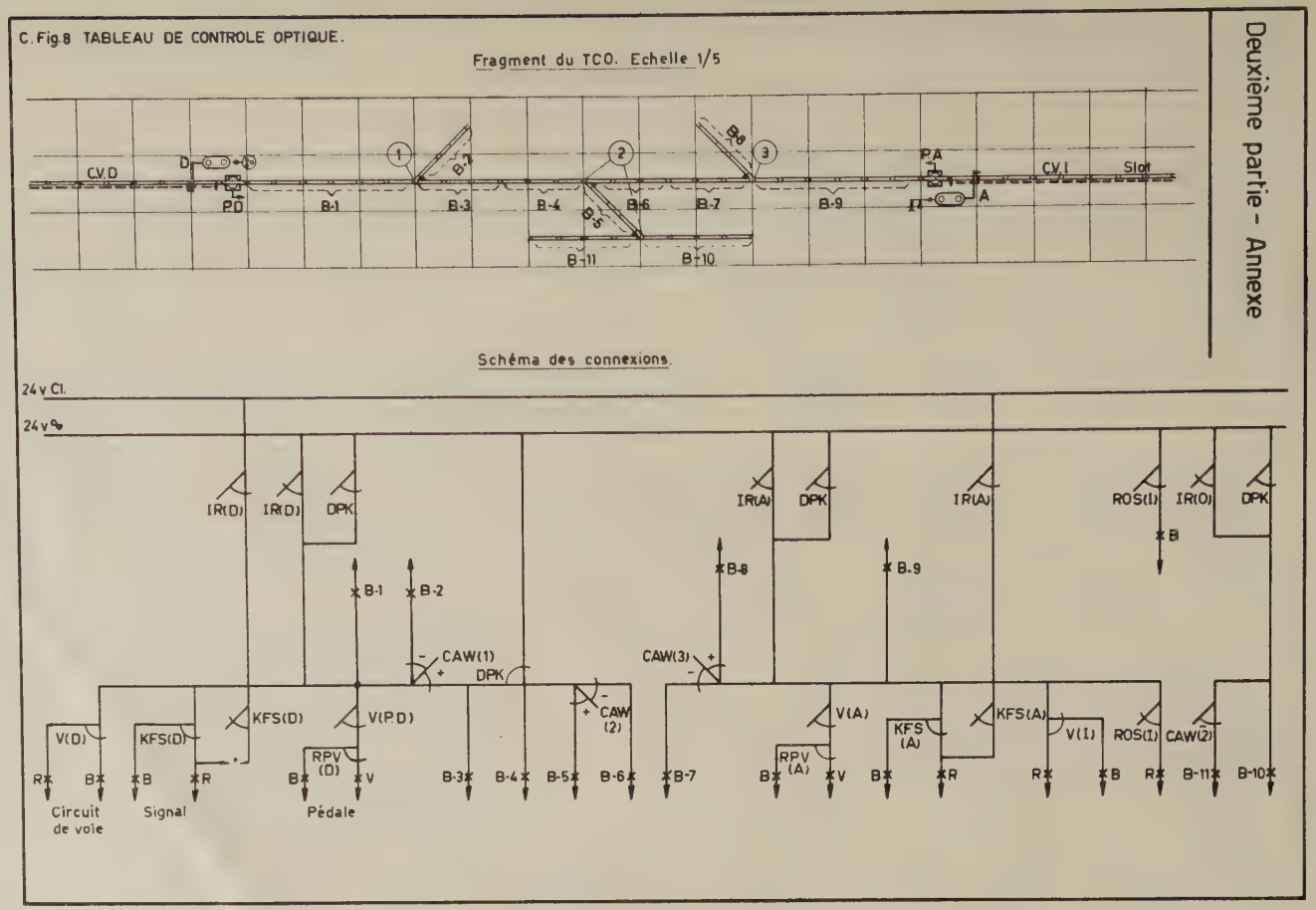


Erratum. — C., fig 7 : To simple contact of the CAW (2) throw over affecting the re-energising circuits should have the sign —.

Translation of the French text :

DEUXIEME PARTIE — ANNEXE = PART TWO — APPENDIX.

C. Fig. 7. Libérations = C. Fig. 7. Releases. — Contrôle sign. à l'arrêt = checking signal at danger. — Contrôle slot normal = checking with normal slot. — Pédale = treadle. — Voies à quai = platform lines. — Vers quais = to platforms. — C. Fig. 7 bis. Enclenchement d'approche = C. Fig. 7 bis. Approach lockings — Circuits de réexcitation = re-energising circuits. — Circuits de maintien = holding circuits. — C. Fig. 9. Pupitre de commande = C. Fig. 9. Operating desk. — Accouplement = coupling. — C. Fig. 10. Zone d'approche. CV de la zone d'approche



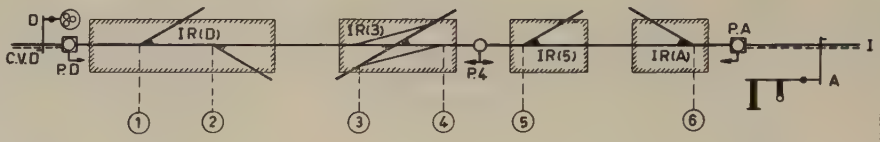
Translation of the French text:

DEUXIEME PARTIE — ANNEXE = PART TWO — APPENDIX.

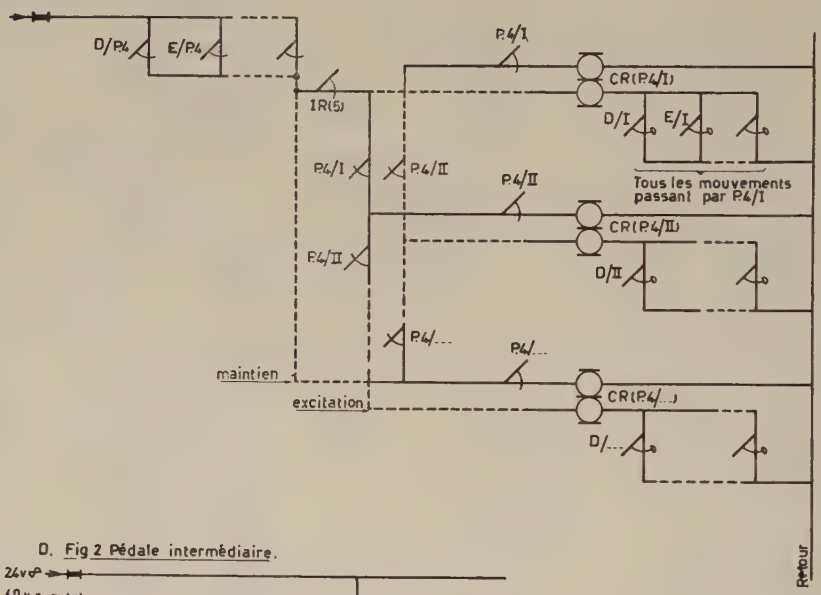
C. Fig. 8. Tableau de contrôle optique = C. Fig. 8. Optical control panel. — Fragment du TCO échelle 1/5 = part of TCO scale 1/5. — Schema des connexions = diagram of connections.

Deuxième partie – Annexe.

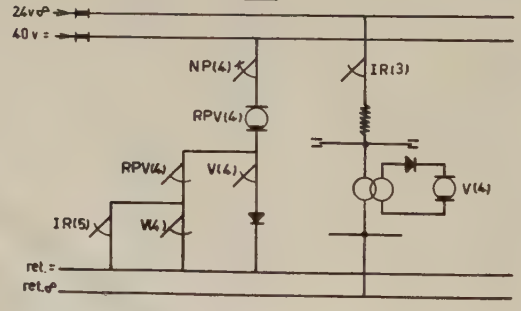
Mouvements avec pédale intermédiaire.



D. Fig.1 Relais CR à la pédale intermédiaire.



D. Fig 2 Pédale intermédiaire.

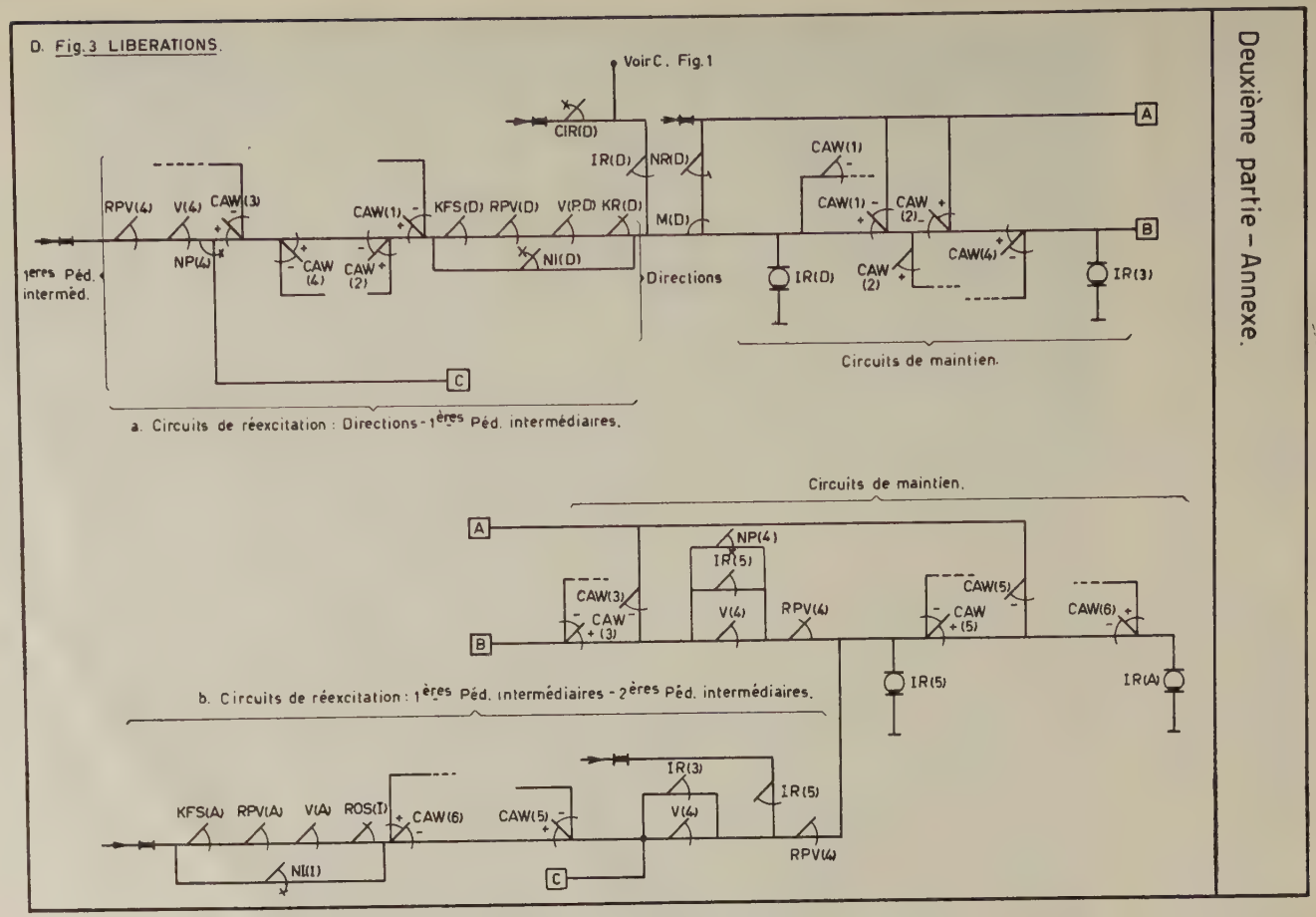


Translation of the French text:

DEUXIEME PARTIE — ANNEXE = PART TWO — APPENDIX.

Mouvements avec pédale intermédiaire — train movements with intermediate treadle.

D. Fig. 1. Relais CR à la pédale intermédiaire = D. Fig. 1. Relay CR at the intermediate treadle. — Tous les mouvements passant par P. 4/1 = all movements passing by P. 4/1. — Maintien = holding. — Excitation = energising. — D. Fig. 2. Pédale intermédiaire = D. Fig. 2. Intermediate treadle.



Translation of the French text:

DEUXIEME PARTIE — ANNEXE = PART TWO — APPENDIX.

D. Fig. 3. Libérations = D. Fig. 3. Releases. — *a*) Circuits de réexcitation : Directions-1eres péd. intermédiaires = *a*) Re-energising circuits : Directions-1st intermediate treadle. — Circuits de maintien = holding circuits. — *b*) Circuits de réexcitation : 1eres péd. intermédiaires — 2mes péd. intermédiaires = *b*) Re-energising circuits : 1st intermediate treadle — 2nd intermediate treadle.

THIRD PART.

NAMUR SIGNALLING BOX.

INTRODUCTION.

Track KX.

a) *Shunting movements to or from track KX;*

b) *Departure movements of trains towards LX.*

CONCLUSION.

THIRD PART.

NAMUR SIGNALLING BOX.

INTRODUCTION.

The new Namur signalling box forms an application of the principles developed in the Second Part of this report.

The signal installations at Namur are in fact operated from two boxes : one (box I or block box 30) operates the part on the Brussels side, the other (box II) the Arlon side. Box I dates from 1914. It was old fashioned and a type since superceded. It had to be renewed. Box II dates from 1925. In a few years time, it will also have to be replaced.

Moreover, on the electrification of the Brussels-Arlon line a re-arrangement of Namur station was decided upon and is in hand. The alterations resulting from this re-arrangement were made as regards the Arlon side in the present Box II. Those on the Brussels side on the other hand cannot be carried out in the present Box I as the necessary equipment is no longer in existence.

The new signal box building is built near box I. The dimensions have been made large enough so that at a future date the operation of the signal installation of the whole station can be done from it. First of all, the renewal of the present Box I will be carried out, then in turn the various stages required to match the new layout on the Brussels side (1).

The new signal box includes an operating table worked by a signalman standing up and by a separate block table. The length of each of these tables is about 1.30 m. The following figures give some idea of the size of the installation.

At the present time it includes :

— thirty seven colour light signals, eleven exclusively for shunting movements;

— sixty one sets of points forming fourteen connections and thirty three switches. With the operating table as installed, one hundred and eighty different and non-selective train movements and four hundred and six selective movements.

When all the alterations have been made the installation will include :

— forty three colour light signals, twelve of which solely for shunting movements;

— seventy-seven points forming twenty six connections and twenty five simple switches. The table will allow the setting up of two hundred and thirty-five different non-selective movements and six hundred and ten selective movements.

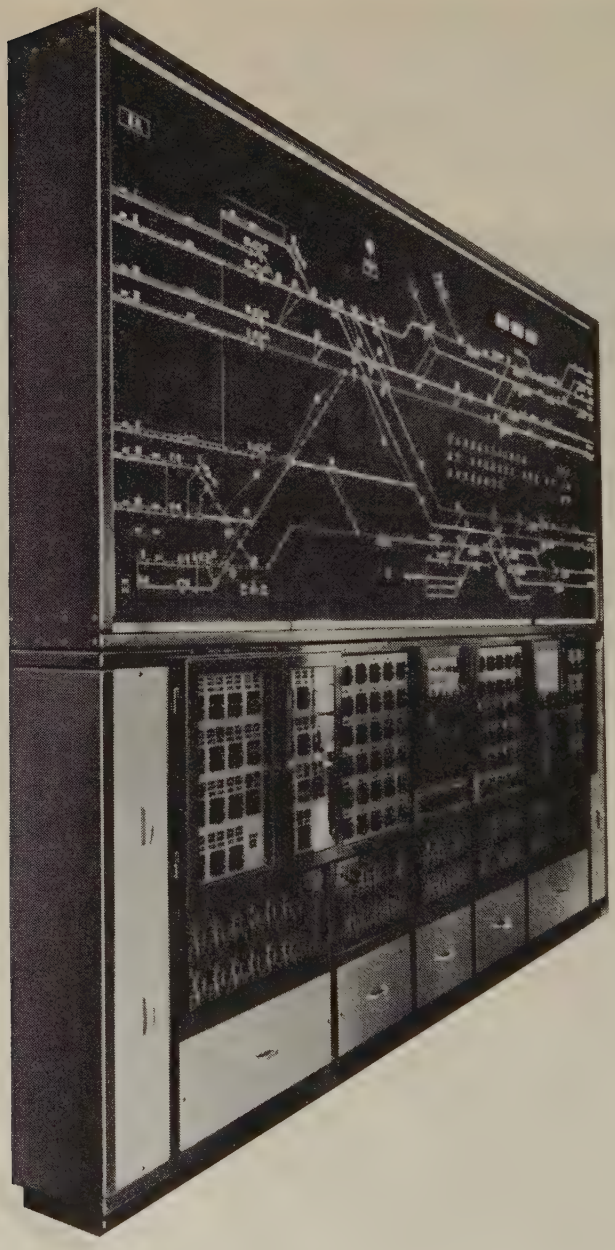
(1) The all relay Namur signal box went into service on the 12th June 1955. It has been entirely satisfactory in operation.

Ultimately, after absorbing Box II, the installation will be some 75 % more important.

The photographs printed below show the type of equipment used. The, as built, drawings of the interior operating circuits as a whole are a strict application of the principles developed in Part II of the report. The layout of one detail has been added to the basic drawings. We have considered previously the effects of setting up simultaneously

The operating desk and the block table (1).

(1) These two desks were built by the Central Signalling Workshops of the Belgian Railways.



The optical control table and the chest for the various keys (1).

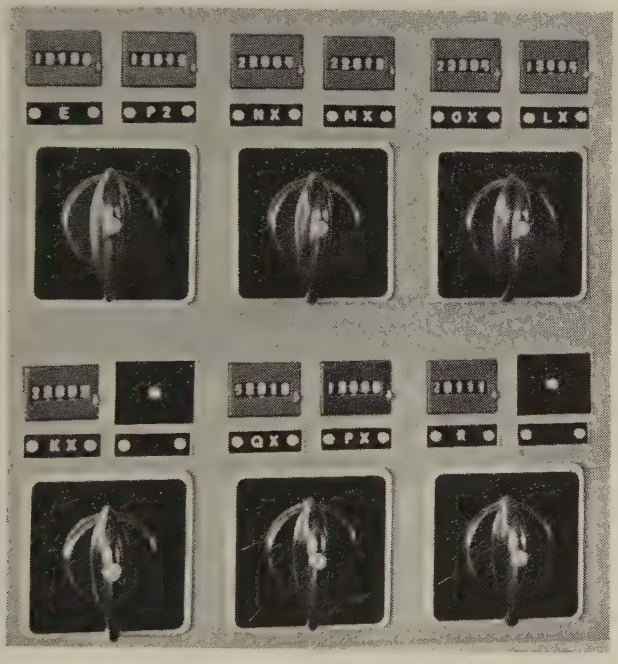
(1) The optical control table has been fitted in the Central Signalling Workshops of the Belgian Railways. It is made of plastic elements manufactured by the firm Vynckier of Ghent. The chest for the various keys was made by the A. B. A. Company of Brussels.

two incompatible movements and came to the conclusion that, in no event, this set up although in principle forbidden would be dangerous. Nevertheless, the setting up simultaneously of three or four incompatible movements may present for the dispositions made and for definite positions of the points some danger of a permissive signal coming off irregularly.

Although these dangerous cases are highly improbable, we have guarded against them in the following manner : on two incompatible movements being set up simultaneously, the points or points making these movements incompatible lose their control unless these points are already locked by a third movement already set up.

To realise this condition, we have bridged the upper position of the locking relay in the layout for operating the CAW throw over (see C., fig. 2, Second Part) by a normally open contact of the series relay of the points (fig. 10). When a set of points originally free is sollicited simultaneously on the right hand and on the left, the series relay remains attracted by its excitation winding as long as this abnormal solicitation persists. As a

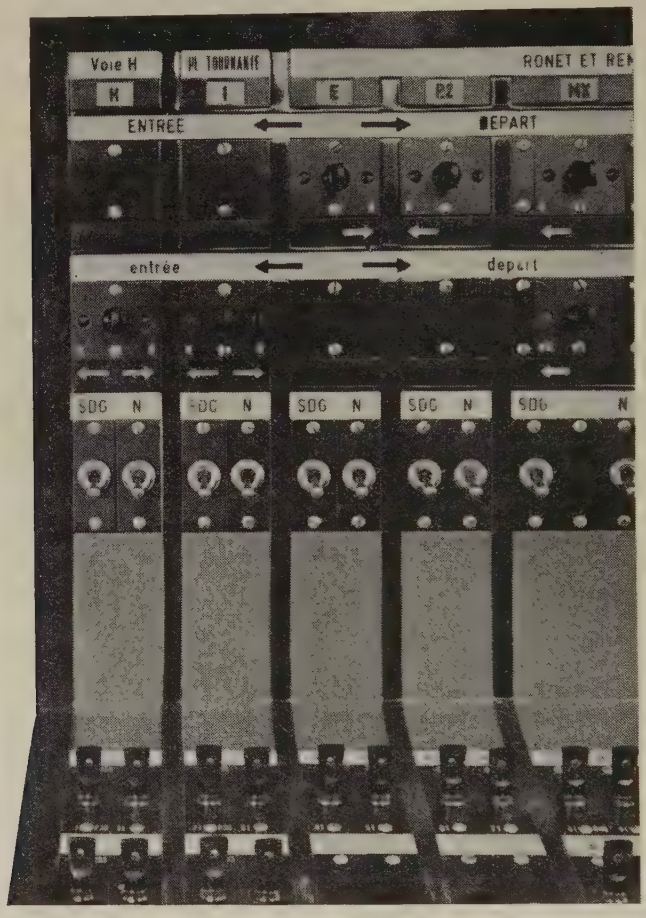
IMMOBILISATION CONTROL.



Details of the chest for the various keys.
Keys to control the locking of the routes.

result the control relay of the points is de-energised and it is impossible to obtain the attraction of the coupling relay by one of the train movements set up.

Moreover, certain particular arrangements of the equipment have involved some alterations in the basic plants. Let us examine one of the arrangements in order to demonstrate the facility with which the basic plans adapt themselves to particular cases.



Details of the operating desk.
Vertical portion : coupling sights, keys for selecting the movement, cancelling the movement and in emergency for putting the signal to danger.
Oblique portion : keys setting up the movement.

LINE KX.

We have defined a train movement as being a run made by a train from one signal to another which follows it, it being understood that the two signals considered have to be obeyed by the train in movement.

From this definition, certain runs are made up of a single movement or of

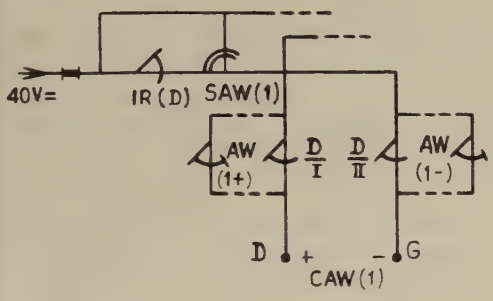


Fig. 10.

two, or of several, according as to whether it is a question of train movements or shunting movements. Let us say that these runs present besides the initial direction one or several intermediate directions.

This is why the line KX serves :

— as initial direction for the shunting movement from or to the line KX;

— as intermediate direction for the departure movements of train towards the initial direction LX;

— as platform for the shunting movements from or to the direction LX.

The operating diagrams relating to the line KX are given in part as appendix to this Third Part.

(a) *Shunting movements to or from line KX.*

Let us take as an example the case of a departure movement when shunting from track EX towards track KX.

The signalman operates the key setting up the movement KX/EX.

The result is that in consequence, in-so-far as an incompatible movement has not been set up :

(1) the operating relays for the route CR (KX/S. 31) and CR (S. 31/EX) are energised;

(2) the throw over relays operating the points CAW for the journey KX (EX) have been put into the required position;

(3) the monokinematic relay M (KX) is energised;

(4) the locking relays IR (KX), IR (40) and IR (EX/CX) fall;

(5) the journey KX/EX appears in broken illuminated lines on the illuminated control board.

The signalman then selects the train movement and causes the relay S (dep. KX) to be energised. A white arrow placed on the selection key lights up on the operating desk.

In the coupling circuits a check is made to see that :

(1) for the direction KX :

that the track circuit KX is free,

that no movement from LX towards KX is in hand (relay IRA (KX) de-energised).

If these two conditions are satisfied the relay IRB (KX) is excited and pre-

vents a movement from LX towards KX being authorised.

(2) to the platform (line EX) :

no condition requires checking;

(3) between platform and direction :

the correct position of the points throughout the journey;

the de-energising of the lock relays IR (EX/CX), IR (40) and IR (KX).

If these conditions are fulfilled the coupling relay KR (KX) is excited. As a result the relay M (KX) drops, the train movement EX/KX is positively locked and the signal EX is moved to clear.

The above described schemes are in all points in agreement with the diagrams setting out the principles.

Let us imagine the rake involved in the train movement be too long to stand between the signals KX and KY. It would be necessary to set back in the direction LX to be able to clear the zone between the signal KX and the platforms. The signalman operates the key of route LX/KX, then selects a departure movement towards LX so provoking according to the same processus as for the journey KX/EX, the excitation of the coupling relays KR (LX) and operates to clear the authorising signal KY.

The rake continues its movement in this way over line KX. Let us suppose that it stops on this line before the signal KX. At this moment the paths between KX and the platforms are free whereas the run LX/KX is locked with the coupling relays KR (LX), the selection relays S (dep. LX) and the route operating relays CR (LX/KX) energised with signal KY off as the train has not run over the treadle LX. Should the signalman have to send the rake towards a platform line (track I for example) he moves the key for setting up the corresponding train movement (KX/I), sets up the movement and locks the movement KX/I with the relay M (KX) excited. He then will select an entry movement from the direction KX towards the platforms. The attraction of the relay S (ent. KX) has the effect of de-energising the relay S (dep. LX). Due to this, the signal KY is restored to danger, whilst the relays KR (LX) and CR (LX/KX) drop. The relay IR (LX) locking the points 48 however is not re-energised because the insulated rail of the treadle LX is occupied. Its de-energised relay V (PLX) prevents the re-energising of the relay IR (LX). The coupling circuit controls the usual conditions and, if these conditions are fulfilled, the relay KR (KX) attracts itself, the relay M (KX) falls and signal KX is taken off.

In addition, current flows towards the relay which takes off signal LX so far as the following conditions are realised :

points 48 locked in the right hand position;

relay CR (LX) de-energised;

treadle LX pressed down and not disengaged with consequently RPV (LX) energised and V (PLX) de-energised.

Once the train movement is begun the signal LX immediately replaces itself to danger as soon as the treadle LX has been cleared. At this moment, the points 48 is freed. In the case in which the treadle LX has not been depressed by the rake being shunted, even when it has reached the insulated rail of the

treadle, the signal LX does not come off. The freeing of the points 48 then occurs as soon as the two following conditions are reunited :

freeing the insulated rail of the treadle LX;

energising of the first relay of the treadle KX RPV (KX).

(b) *Starting of trains towards LX.*

Let us suppose a train leaves from track EX. The signalman operates the route setting up key LX/EX. The result is :

(1) to energise the operating route relays CR (LX/KX), CR (KX/S. 31) and CR (S. 31/EX);

(2) to put into the proper position the throw over relays CAW for the journey LX/EX;

(3) to energise the monokinematic relays M (LX) and M (KX);

(4) to drop the locking relays IR (LX), IR (KX), IR (40) and IR (EX/CX);

(5) to show in broken illuminated lines the journey LX/EX on the optical control board.

The signalman then selections the movement and causes the energising of the relay S (DEP. LX).

Two coupling circuits are affected by the movement. One results in the energising of the relay (KR/KX) and controls the usual platform conditions between KX and EX to the direction KX. The other leads to the energising of the relay KR (LX) and in addition to the usual conditions also checks that the relay KR (KX) is attracted and the relay M (KX) de-energised. The attraction of the relay KR (LX) causes the fall of the monokinematic relay M (LX) and takes off the signal EX.

The various liberations present no particular characteristic.

CONCLUSION.

We hope in the Second and Third Parts of this report to have shown the relative simplicity of the diagrams of principle described as also the ease with which these diagrams can be adapted to particular cases. To a large extent, these good features result from the small number of relays essential to the completion of the signalbox. Besides the treadle relay, track circuit, slot, signal operating gear required in all cases the following equipment is used :

(*a*) per points, a group comprising :

a throw over relay CAW;

a series relay SAW;

a control relay KAW;

a differential relay KTA;

(*b*) per zone of incompatible points :

a route locking relay IR;

(*c*) per route :

a route operating relay CR;

(*d*) according to the direction and per kind of movement :

a selector relay S;

(*e*) per direction :

a coupling relay KR;

a monokinematic relay M;

Experience has shown that the small number of relays does not engender as a consequence an excessive number of contacts per relay. For example at Namur, most of the route operating relays have twelve or sixteen contacts. The selector relays, the monokinematic relays and the coupling relays have eight to twelve contacts as have almost the whole of the locking relays. The relays for throwing over the points have thirty two contacts. The advantage of simplicity is linked to an economical cost of installation. We hawe already pointed out that the saving can be evaluated at about 20 % of the price of inside installations as previously provided. In the case of the Namur box, this economy represents in absolute value about 700 000 Belgian francs.

The basic layouts can have a large number of variants whilst still being based on the same rules. Let us give two as examples :

(1) it is possible to set up and select a movement by a single key instead of two. This layout however has the drawback of increasing appreciably the dimensions of the operating desk in important boxes.

Under this supposition, the energising of the selecting train movement relays will depend upon the attracted position of the route locking relay IR for the direction concerned exactly as for the relays operating the route. It is moreover possible occasionally to economise, in this case, selector relays, by adopting the de-energised position of the selector relay to indicate a movement and the attracted position of the same relay to identify another movement;

(2) It is also possible to carry out coupling circuits using alternating current at the feed voltage of the relays placing the signals to the off position. Under these conditions, the relays, which take the signals off, will be fed through in the coupling circuits, the coupling relays KR being energised on a shunt branch (fig. 11). This method has the benefit of making certain the authorising signal goes to danger on the event of one

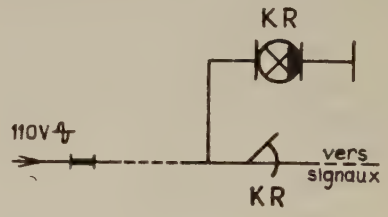
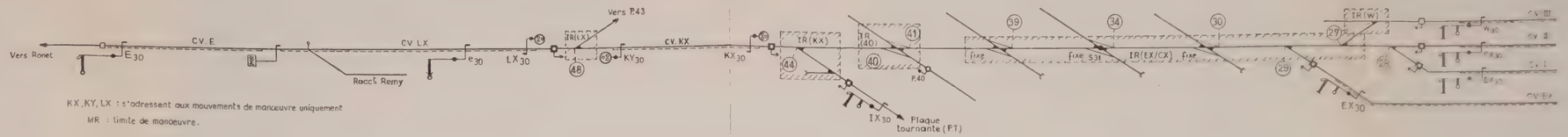


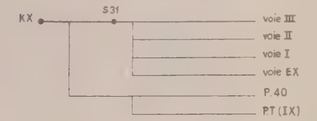
Fig. 11.

of the conditions necessary, if the signal is to be taken off, should be wanting even if through a defect in construction the coupling relay remains stuck mechanically. It has the disadvantage of causing the signal set to off to go to danger unexpectedly in the event of a defect on the normal source of supply, and switching on to an emergency supply unless the coupling relay is sufficiently delayed before falling to remain attracted during the switching over of the supply.

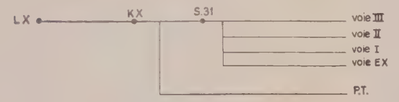


Itinéraires

Manœuvres de et vers KX (entrée + départ)



Départs de trains vers LX (DEPART)



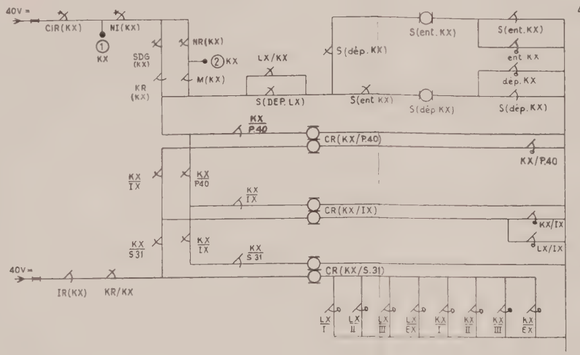
Position aiguillages.

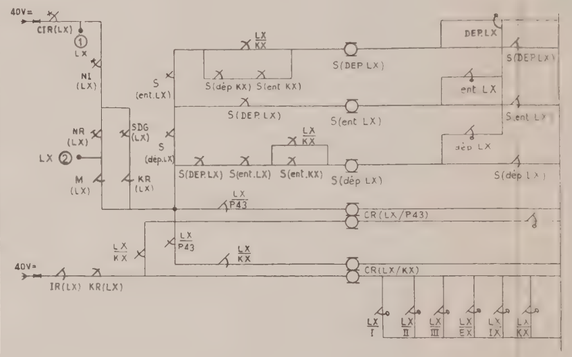
KX - S31	=	34.39.40.41.44
KX - IX	=	44
KX - P.40	=	41.44 / 40
S31 - III	=	27.29.30
S31 - II	=	28.29.30 / 27
S31 - I	=	29.30 / 27.28
S31 - EX	=	30 / 29 (27)
LX - KX	=	48

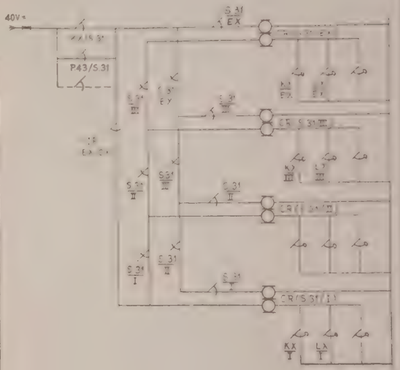
Légende $\frac{1}{}$ = aiguillage 1 à gauche

$\frac{}{1}$ = aiguillage 1 à droite.

Relais de commande de route et sélection. (Direction KX – Direction LX - Point de sectionnement S.31)

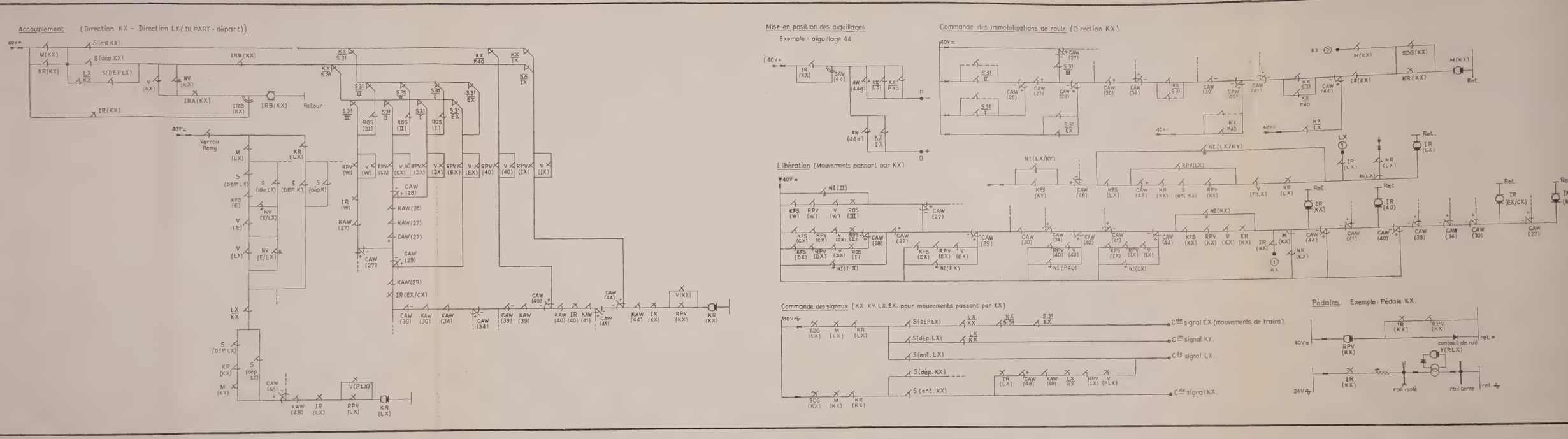






Translation of the French text:

Vers Ronet = to Ronet. — Racc.s Remy = Remy siding. — KX, KY, LX : s'adressent aux mouvements de manœuvre uniquement, MR : limite de manœuvre = KX, KY, LX: relate solely to shunting movements, MR: limit shunt. — Fixe = fixed. — Plaque tournante (PT) = turntable (PT). — Routes = routes. — Point de sectionnements 31 = section end 31. — Manœuvres de et vers KX (entrée + départ) = Shunts to or from KX (incoming and leaving). — Départs de trains vers LX (DEPART) = Departures of trains to LX (DEPARTURE). — Voie = track. — Position aiguillages = position of the points. — Légende $\frac{1}{}$: aiguillage 1 à gauche, $\frac{}{1}$: aiguillage 1 à droite = Note $\frac{1}{}$: points 1 to the left, $\frac{}{1}$: points to the right. — Relais de commande de route et sélection (Direction KX — Direction LX — Point de sectionnement S.31) = path and selection operating relays (Direction KX — Direction LX — Section limit S.31).


Accouplement (Direction KX - Direction LX (DEPART - départ))
Verrou Remy
Mise en position des aiguillages
Exemple : aiguillage 44.
Commande des immobilisations de route (Direction KX)
Libération (Mouvements passant par KX)
Commande des signaux (KX, KY, LX, EX, pour mouvements passant par KX)
Pédales. Exemple : Pédale KX.
contact de rail
rail isolé
rail terre

Erratum. — Couplings : The contacts lettered S(DEP. K) and S(dep. K) should read S(DEP. LX) and S(dep. LX).

Erratum. — Operating route lockings : The simple contact of the relay CAW 30 should be marked — and not +.

Translation of the French text :

Accouplement (Direction KX — Direction LX (DEPART = départ)) = coupling (Direction KX — Direction LX (DEPART = departure)). — Mise en position des aiguillages, Exemple : aiguillage 44 = placing points in position, Example : points 44. — Libération (Mouvements passant par KX) = releasing. Movements passing by KX. — Commande de signaux (KX, KY, LX, EX pour mouvements passant par KX) = operation of signals. KX, KY, LX, EX for movements passing by KX). — Commande des immobilisations de route (Direction KX) = operation of route locking (Direction KX). — Pédales, Exemple : pedale KX = treadles, Example : treadle KX. — Contact de rail = rail contact. — Rail isolé = insulated rail. — Rail terre = earth rail. — Ret = return.

Geophysical site investigation methods applied to civil engineering works,

by J. DUBUS,

Ingénieur en Chef honoraire de la Société Nationale des Chemins de fer belges.

In September, 1955, the Institution of Civil Engineers, London, published an excellent paper by two engineers specialised on soil mechanics, Mr. Jack ROBERTSHAW, B. Sc., A.M.I.C.E. and Mr. Philip Duncan BROWN, B. Sc. (Eng.), A.M.I.C.E.

This paper, illustrated by very interesting applications, has been the subject of discussions at the Institution, which confirm the present trend and the value of the application, by specialized firms, of these comparatively new methods.

These geophysical soil investigation methods, carried out on the surface, have been developed in the United States during the past 20 to 30 years for the detection of oil fields and metal deposits and in order to elucidate problems of a stratigraphic or tectonic nature.

In 1932, SCHLUMBERGER and LÉONARDON described, in the *Annales des Ponts et Chaussées*, France (1), the application to the study of tunnel and dam projects of electrical surveys, one of the methods discussed at length at the Institution of Civil Engineers, the other method being the seismic method based on the shock refraction of the earth's crust provoked on the surface.

In the British Commonwealth, specially in Canada, and also in Germany, more and more use has been, and is being, made of these types of surveys for dam foundations or for the study of new roads and railways, tunnels and pipelines.

In outlining the principles of these methods, it is useful to have recourse to the lectures given at Yale University by Dimitri P. KRYNINE (3).

In his study of electrical sub-soil surveys, published by Gauthier-Villars (Paris), in 1920, SCHLUMBERGER was one of the first to deduce the position and composition of deeplevel soils from single measurements of the resistivity of the geological formations of which the subsoil consisted.

If an electrode A is driven into the soil (says Charles MONDIN in his manual on « Public Works » [2]), passing into the soil a current with the intensity I, which is assumed to be returned by a distant earth return; wholly surrounding A, the current flows along straight lines through the soil in such a way that the ohmic resistance of the soil is reflected in a decrease in the potential, and the surfaces forming the loci of all points of equal potential are spheres around A as a centre.

If $\frac{dV}{dr}$ is the radial decrease in the potential over a distance r from A, I the intensity of the current and ρ the resistivity

of the subsoil, Ohm's law, as applied between two such spheres, yields :

$$\frac{dV}{dr} = \frac{\rho I}{2\pi r^2},$$

of, after integration :

$$\rho = \frac{V}{I} \times 2\pi r$$

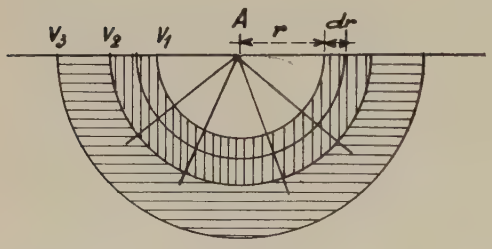


Fig. 1.

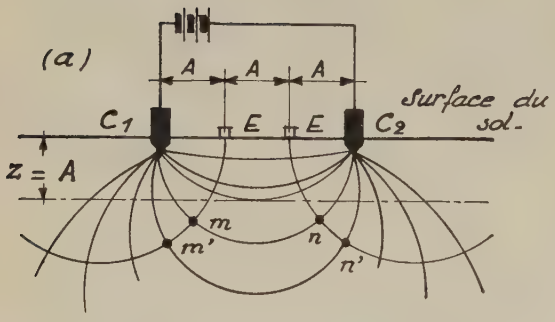


Fig. 2. — Surface du sol = soil surface.

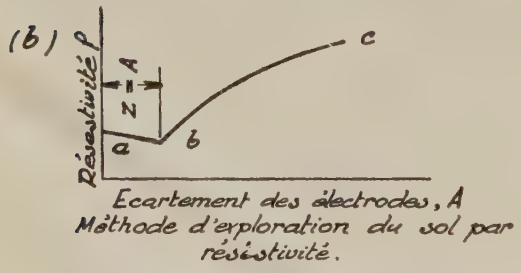


Fig. 3. — Earth resistivity method of soil investigation.

Résestivité = resistivity
Écartement des électrodes = distance between electrodes.

an equation which we shall apply in Krynine's treatise.

I. — *Electrical method.* — An electric current is made to flow in the soil between two electrodes C_1 and C_2, sufficiently distant from each other. The lines forming the loci of equal potentials are drawn up normal to the current circuits. The potential is thus the same at *m* and *m'*. It is equally the same at *n* and *n'*. The decrease in the potential between *m* and *n* is equal to that between *m'* and *n'* and can be measured on the surface by means of a potentiometer between the electrodes EE.

The electrodes are so arranged that the distances C_1E, EE and EC_2 are, equal amounting to A centimetres.

The resistivity of the earth ρ expressed in ohm centimetres, i.e. the resistance between two parallel faces of one cubic centimetre of earth, amounts to :

$$\rho = \frac{2\pi A.E}{I}$$

By varying the distance A, one obtains different values for the specific resistance ρ of the earth at different depths. The curve, illustrated here, shows ρ as a function of A. It begins as a straight line *ab*, slightly dropping over a distance Z = A which corresponds to the thickness of a covering layer of clay and sand. Point *b*, defined by Z = A, marks a discontinuity, whilst the ascending curve *bc* indicates a rock formation of high resistivity.

II. — *Seismic method.* — Sound waves are propagated in sand or clay formations at velocities varying between 1 000 and 6 000 ft. pr. second, but in rock at speeds of the order of 16 000 to 20 000 ft. pr. second.

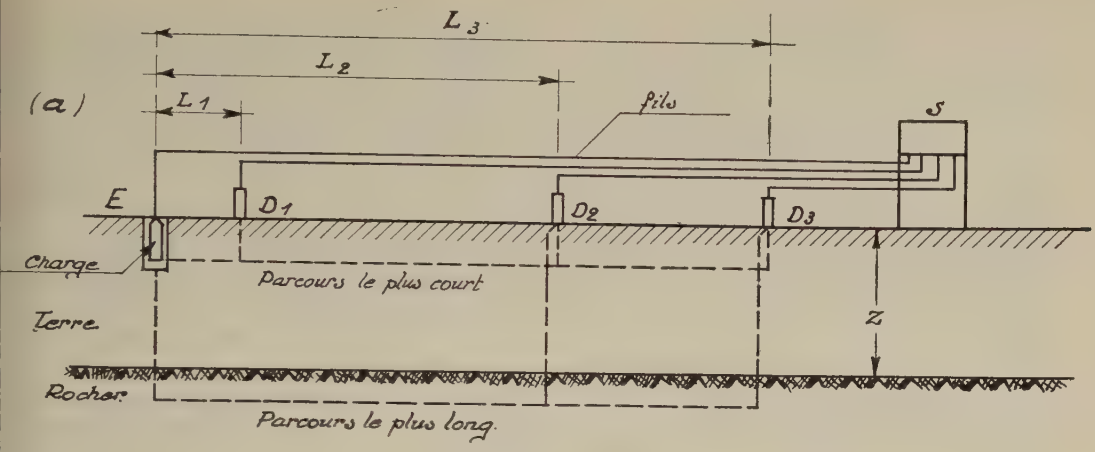


Fig. 4.
Fils = wires. — Terre = soil. — Rocher = rock. — Parcours le plus long = longest distance. — Parcours le plus court = shortest distance.

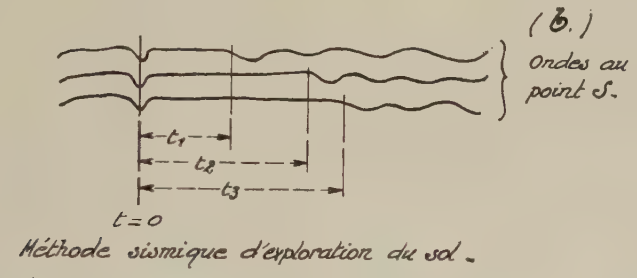


Fig. 5.
Méthode sismique d'exploration du sol = seismic soil investigation method. — Ondes au point S = waves at point S.

At E, a light dynamite charge is exploded. E thus becomes a shock centre, the sound waves are propagated in all directions, though only the one travelling towards the seismograph S is shown in the drawing.

The detectors D_1, D_2 and D_3 are actuated by this shock and transmit the impulse which they receive to three galvanometers which record the phases of the phenomenon on a photographic film. With the aid of a wire wrapped around the explosive charge, the time $t = 0$ of the explosion is similarly recorded. So are the times t_1, t_2 and t_3 at which detectors D_1, D_2 and D_3 are actuated.

These impulses may be received first through the overburden and then through the lower rock, or vice versa, as the photographic film will show. Knowing the distance L_1 of detector D_1 from the shock centre E as well as the time t_1, the velocity of propagation in the over-

burden, V_s, amounts to :

$$V_s = \frac{L_1}{t_1}$$

In order to reach detector D_3 through the rock, the sound wave must traverse twice the thickness of the soil, i.e. 2Z, at the velocity V_s indicated above, plus the horizontal distance L_3 at the velocity V_r in the rock. One thus obtains for detector D_3 :

$$t_3 = \frac{2Z}{V_s} + \frac{L_3}{V_r}$$

so that the thickness Z of the covering layer can be worked out.

The results can be verified by using a greater number of detectors.

It may happen that a detector is actuated simultaneously by the wave in the overburden and the wave through the rock. In this case, the detector is said to have a critical distance L_{cr} from the explosion centre, approximately related to the thickness of the overburden by the equation $Z = 0.45\ L_{cr}$. All these cases are commented upon at length in the paper by Messrs. ROBERTSHAW and BROWN.

We might add that the « Deutsche Forschungsgesellschaft für Bodenmechanik » (DEGEBO) Berlin (5) provokes the shocks by means of a vibrator (Schwingungserzeuger), consisting of two eccentrically supported disks and turning in opposite directions. What are the advantages of these geophysical methods? They are : rapidity and economy of execution. It is possible to cover, by these means, a large surface with a close mesh of observations, thus eliminating, as SCHLUMBERGER points out, the hazards of interpolation between costly and dispersed borings.

The code of practice for site investigations, published by the Institution of Civil Engineers (6), which describes these different geophysical methods (Appendix K), insists on the need to carry out occasional confirmatory borings in order to appraise the accuracy of the survey. With this qualification, the members of the Institution of Civil Engineers are of the opinion that these methods are destined to have a great future. This opinion is confirmed by articles which have appeared in the German journal « Die Bautechnik » (4), and by certain conclusions arrived at by the Road Congress.

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(2) Charles MONDIN, « *Travaux Publics* », Volume I, published by Dunod, Paris.

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(4) Dr. Volker FRITSCH, Vienna, « Geo-elektrische Baugrund-Untersuchung » *(Geo-electrical surveys of building sites)*, « *Die Bautechnik* », October 1954.

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(6) Site investigations, Code of Practice published by the Institution of Civil Engineers, London.

(*) We are indebted to M. Pierre DUBUS, engineer with the Belgian National Railways Company, for the research work carried out to elaborate this article.

[625 .143 .3]

The enigma of rail corrugation on railways,

par Dipl.-Engineer Kuno SPADERNA, Worcester, Massachussets, (U.S.A.).

(*Glasers Annalen*, February 1955.)

Foreword : Following upon several other contributions on this subject published in the above named publication the Editor publishes below the new theory on rail corrugation. Without expressing an opinion of his own, he wishes to make a contribution to the clarification of this question by providing the widest possible scope for its study and discussion.

Introduction.

For about 60 years (1), the Railway Administrations have carried out research to detect the causes of the corrugations encountered on rails used by trains running at high speeds. With the increase in running speeds, these corrugations have increased to such an extent that the question can be said to be one of the most burning problems on the railways. Some engineers blame the foundations, below the ballast, as they found that the same rail, transferred from a main line to a secondary line, lost its corrugations. In 1921, WICHERT (2) published a theory which has been widely accepted up to now, and which attributes rail corrugation to the oscillations caused by the friction of the axles. It is assumed that, owing to the difference in the friction coefficients along the rail, slipping occurs sometimes at one wheel, sometimes at another; through the resulting torsion in the axle, the lagging wheel is accelerated and, in the process, tears out the metal of the rail. GEIGER (3) adapted the formula of the torsion oscillations to the axle characteristics and found, for the inherent frequency per minute :

$$n = \frac{30}{\pi}\sqrt{\frac{I\,G}{R^2\,l\,m}},$$

where : I = moment of inertia of the axle, G = 0.385, E = modulus of shearing, R = wheel radius, l = length of the elastic wave between the wheels, m = mass of the wheel related to the wheel radius (system-centimetres). One thus obtains a torsion oscillation of about 50 cycles and, for a running speed of V = 11 km (6.8 miles)/p.h., corrugations of 6 cm (2.36 in.) length. For a speed of V = 90 km (56 miles)/p.h. one obtains corrugations of 0.5 m (1' 7 1/16") length. The actual corrugations encountered on European main lines have a wave length of μ = 4.5 to 4.75 cm (1.77 to 1.85 in.). Longer wave lengths of 0.5 m and more are also encountered, but these cause no trouble, either in respect of noise or in respect of wear.

The enigma of the short-wave corrugations is made even more complicated by the fact that the pits between the crests are much too narrow for the curvature of the wheel. The corrugations are therefore not simply produced by abrasion. Suspecting

(1) FINK : « Die Entstehung der Schienenriffeln. — Der Stand der Riffelforschung nach rund 60 Jahren » (The origin of rail corrugation. Results of rail corrugation research after about 60 years). *Glasers Annalen*, 77 (1953), No. 11, pp. 342-350, and No. 12, pp. 373-380.

(2) WICHERT : « Eine neue Theorie der Riffelbildung » (A new theory of rail corrugation). *Verkehrstechnik*, Vol. 33, 34 (1921), No. 9, pp. 109-113 and No. 10, pp. 140-143.
WICHERT : « Untersuchung der durch Reibschwingungen verursachten Riffelbildung » (Examination of rail corrugation caused by friction vibrations), *Zeitschrift des Vereins Deutscher Ingenieure*, 70 (1926), p. 1017 and seq.

(3) GEIGER : « Untersuchung der Riffelbildung an Schienen mit Hilfe des Torsiographen » (Examination of rail corrugation by means of the torsiograph). « *Zeitschrift des Vereins Deutscher Ingenieure* », 68 (1924), No. 12, p. 283 and seq.

that the cause of rail corrugation was to be found in the natural vibrations of the track, we have carried out, since 1950, measurements on German rails and have found frequencies above 300 cycles per second. The idea that the superstructure of the track, which is of such rigid appearance, could vibrate at such frequency was abhorrent to veteran engineers. They recalled previous measurements of this kind (4). It was therefore necessary to confirm the presence of high frequency vibrations by means of instruments other than the old electromagnetic oscillometers. Moreover, it was necessary to show, by the calculation, the origin of the frequencies, which is the main subject of the present treatise.

Theory of the origin of corrugations.

The rail vibrates with nodes located on the centre line along which it is effectively fixed. This line may pass either through the centre or, if the fastening is slack, through the edge of the sleeper slips. The rail sections corresponding to the different spans are lifted before they are reached by the carrying wheel of the locomotive. In this condition, they vibrate at fairly high frequencies which depend on the sleeper spacing (i.e. the length between fixing points) and on the rail profile. The only vibrations which have a bearing on the considerations that follow are the *vertical bending vibrations*, but the knowledge of the other vibrations is useful in separating them in the oscillograph (5).

A rail of standard profile S 49 vibrates during the passage of an express train at a frequency of about 535 cycles and with an amplitude of about 0.3 mm. As the node of these vibrations is fixed, the wheel is adapted to the rhythm of the rail. High pressures are exerted on the small contact surfaces which result in a kind of hardening process (corrugations) (6). What has been ascribed to the friction vibrations of the wheels is thus caused by the rail itself. Why is it that, under these circumstances, the wheel does not show corrugations? Is it not the wheel that deadens the shocks? The wheel wear is uniform over the whole circumference, making allowance for the fact that the tread circle varies because of the conicity. The rail, on the other hand, does not shift. As figure 1 shows, the sleeper tilts in the vicinity of the load, the effective fixing moves from the bolt towards the left-hand edge of the clip. In consequence, the distance between fixed points on the right, d, is increased by Δd, whilst that on the left is decreased by Δd. As a result, there is a certain scatter in the frequency values, and the node is slightly displaced according to the wheel load. On the whole, the corrugations are regular. Their height may attain 0.3 mm, and their length 4.5

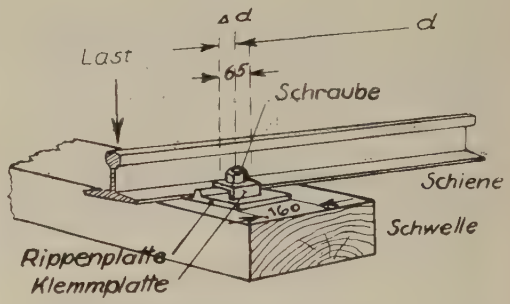

Fig. 1.

Last = load. — Rippenplatte = ribbed plate. — Klemmplatte = clip. — Schwelle = sleeper. — Schiene = rail. — Schraube = bolt.

(4) SALLER : « Dynamik und Schwingungen des Eisenbahnoberbaus » (Dynamics and vibrations of railway permanent way). *Zeitschrift des Vereins Deutscher Ingenieure*, 72 (1928), p. 1323 (see also p. 1255 and seq.)

(5) ADLER : « Eigenschwingungen des Systems Schiene-Schwelle » (Natural vibrations of the rail-sleeper system). *Organ für die Fortschritte des Eisenbahnwesens* 90 (1935), No. 3. (This contribution is based on American measurements.)

(6) M. MONNET and H. PALMÉ : « Contribution à l'étude des causes de l'usure ondulatoire » (Contribution to the study of rail wear through corrugation). *Revue Générale des Chemins de fer*, 70th year, February 1951 (Examination of the hardening phenomenon).

to 4.75 cm in Central Europe, and 3" (7.6 cm) in the United States.

Assuming that an express train runs at a speed of V = 87 km (54 miles)/p.h., i.e. about 2 420 cm pr. second, one obtains, through dividing by 535, a corrugation length of 4.52 cm (1.77 in.). How is it that slow trains do not smooth out these « standard » corrugations by provoking shorter ones?

Influence of running speed and sleeper spacing.

The answer to this question has been found in an empiric law, according to which the maximum vertical accelerations, expressed in g = 981 cm/sec^2. (i.e. the gravity acceleration), amount to :

$$a = \sqrt{110 \times V} \times f/535 \qquad (1)$$

where : V = the running speed in km.p.h. of the train which causes the rail to vibrate; f = the predominant frequency of the vertical bending vibrations in cycles pr. second; 535 = the predominant frequency for a sleeper spacing of 65 cm, usual for Central Europe.

The maximum accelerations, which attain 100 g, apply if the frequency f is not higher than 534. If f is higher than 535, a becomes 1.5 times greater.

The formula shows that a lower running speed causes reduced accelerations, and therefore weaker forces. The corrugations are therefore determined by the *fastest trains*, though the frequency of these trains compared with the remainder of the traffic also has a certain influence. It is obvious that a light locomotive could not outweigh the influence of several thousand axles per day.

It may be noted in passing that f and a vary considerably as soon as corrugations exist. In the vibrations diagram, the amplitudes of the corrugation frequence therefore predominate, with a forced frequency of :

$$n = r \times v,$$

where : r = the distribution of the vibrations in cm, and v = the running speed in cm/sec.

The predominant vibration, i.e. that vibration which yields the maximum amplitudes in the accelerations oscillograph, can be determined by calculation. It depends on the distance between the fixed points of the rail which is practically equal to the sleeper spacing. The natural frequencies of the bending vibration of any order i (7), in cycles per second, are :

$$f_i = \frac{k_i^2}{d^2} \sqrt{\frac{E\,I}{s\,F}} \qquad (2)$$

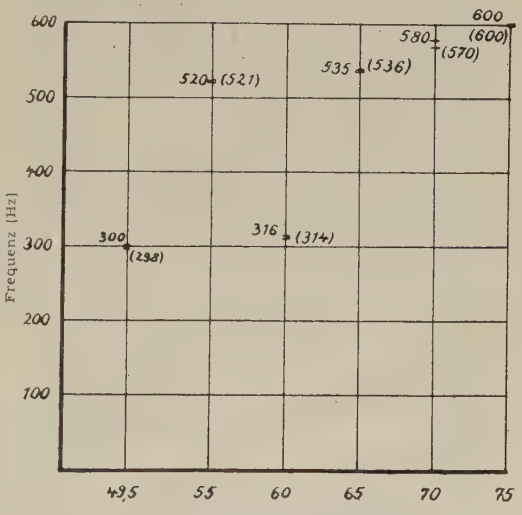

Fig. 2. — Mean values of the predominant frequency of the rail, measured and (in brackets) calculated.

American rail	Sleeper spacing.
AREA-100	S 49 rail
J = 2 020 cm^4	J = 1 795 cm^4
F = 64.1 cm^2	F = 62.48 cm^2

where E = modulus of elasticity of cast steel = 2.1 × 10^6 kg/cm^2; I = moment of inertia of the rail in respect of its horizontal centre line, in cm^4; s = specific weight of the metal = 7.5; F = cross-sectional area of the rail in cm^2; d = distance between the centres of the clips of adjacent sleepers;

(7) *Hütte I.*, Vol. I, 26th Edition, p. 437. Bars possessing mass, without lumped loads (Formula for the natural frequency of the bending vibration with coefficients for a beam fixed at both ends).

coefficients $k_1^2 = 22.35$; $k_2^2 = 61.7$; $k_3^2 = 120.9$; $k_4^2 = 198.5$; $k_5^2 = 297$.

With the aid of this formula, it can be determined whether multiples of these frequencies *fi* coincide with, or are close to, the resonance. The resonance frequency is the value of the predominant vibration. If there are two resonance frequencies as for $d = 75$ cm, it is the one giving the greatest resonance proximity which enters into equation (1) : $6 \times f_4 = 600$, $4 \times f_3 = 599$. This resonance is clearer than $8 \times f_3 = 485$, $5 \times f_4 = 500$. To these two frequencies correspond the measurements $a = 160g$ at 600 cycles, and $a = 113\,g$ at 500 cycles. Calculation and measurements relate to a test track of S 49 rails at Eschweiler, near Düren (Rhineland).

Figure 2 shows the frequencies *f* measured and calculated for different sleeper spacings. As we have explained with the aid of figure 1, these values must show a certain scatter. This has been found to be $\pm$ 4 %, which is surprisingly small in view of the creeping of the sleepers.

The values for $d = 49.5$ cm have been obtained in the course of research work carried out by the author in America (Worcester, Mass.). In the vicinity of the section where the measurements were taken, the rail AREA-100 ([8]) showed corrugations of a length of 3" (7.6 cm) which corresponds to the predominant frequency found at V = 81.5 km(51 miles)/p.h. The measurement showed V = 80 km (50 miles)/p.h. These American figures provide an excellent corroboration of the theory.

([8]) « Marks' Handbook for Mechanical Engineers », published by Mc Graw Hill Book Company, New-York, 1951.

Summary.

For a given running speed of express trains, the acceleration of the bending vibrations is proportional to their *predominant frequency f* (equation 1). This frequency determines the length of the corrugations and the rapidity of their progression. It represents a resonance of harmonics, the first of which must be calculated in accordance with equation (2).

The sleeper spacing *d*, which is practically equal to the distance between the fixed points of the rail, represents that variable which has the greatest influence on the fundamental oscillations. According to figure 2, the values $d = 50$ cm and $d = 60$ cm are particularly favourable, whilst the values $d = 70$ cm and $d = 75$ cm are particularly unfavourable.

The corrugations result from an infinity of very brief shocks of the rail against the wheel which is partly carried along in forced vibrations (axle play). It is only when this hammering regularly hits the *same spots* on the rail that a series of corrugations can results. It would therefore be advisable to place, in a pronounced curve where *d* differs on the inner rail and the outer rail from the previous fixing distance, a rail on which corrugation has recently been encountered. Moreover, a profile for which the ratio I/F is as small as possible (large base) yields predominant frequencies of moderate magnitude.

NEW BOOKS AND PUBLICATIONS.

[**313 : 656** (494)]

Schweizerische Verkehrsstatistik *(Swiss Transport Statistics)* **1954.** — One volume (8 1/4 × 11 1/2 in.) of 157 pages with 7 graphs. — 1955, Berne. Published by the *Federal Transport Office*, (Price 12 Swiss francs).

These statistics, now issued for the seventh time, cover the whole of the transport methods used in Switzerland : railways with general traffic, special railways, local traffic systems, road traffic by motor vehicles, navigation, airways.

The statistics relating to the railways with general traffic are the most detailed. They include data concerning the constitution of the lines, the rolling stock, the routes, the traffic, the financial results, and constructional costs.

On the C. F. F., the traffic has evolved in a satisfactory way whereas those private railways sharing in the general traffic have experienced divers fortunes.

The group of special railways includes the the rack railways, the funiculars and the telpher railways. Overhead lines are still in full expansion : 13 new telpher railways were opened, which increased their total number to 62 with a total length of 121 km (74 miles). The traffic was affected by the bad weather of the summer of 1954.

For local traffic, tramways, trolleybuses, gyrobuses and motor buses are used. Here the number of passengers carried has again increased, rather more so on the buses than on the tramways.

Road traffic continues to increase. The number of motor vehicles continually increases. On the other hand, international transport both in private cars and in foreign cars has increased and the traffic carried by Swiss and foreign lorries even more so.

The report gives interesting details about the navigation on the Swiss lakes and on the traffic at the two ports of Bale on the Rhine. This latter, chiefly to inland destinations, mostly goes on by rail, but here again motor competition is very strong.

As far as air services are concerned, there has been an increase in the number of services and a very great augmentation in the amount of traffic carried, with the receipts showing a greater upward curve than the costs.

The seven graphs included at the end of the book show the evolution during recent years of certain carefully selected factors giving a good idea of the prosperity of the Swiss transport undertakings.

E. M.

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